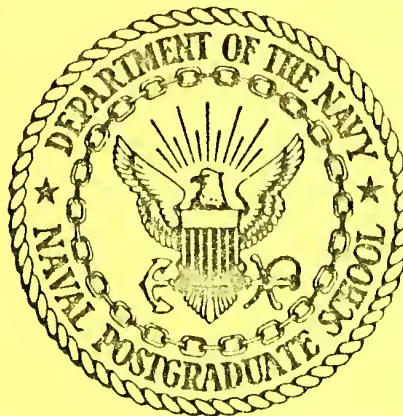


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Monthly and Seasonal Climatology over the  
Global Tropics and Subtropics  
for the Decade 1974 to 1983

Volume II. Outgoing longwave radiation

by

James S. Boyle and K.-M. Lau

August 1984

Technical Report

August 1983 - August 1984

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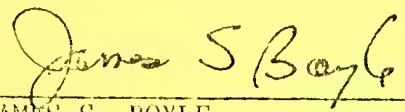
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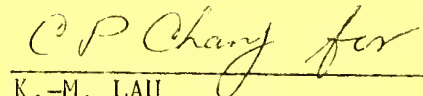
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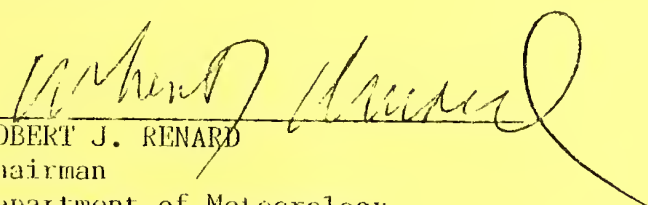
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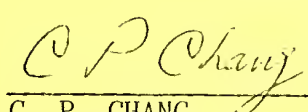
  
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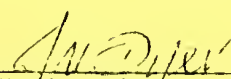
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This atlas of the outgoing longwave radiation (OLR) contains northern winter monthly and seasonal fields from 40S to 60N over a global belt for the winter (December, January, February) during the decade 1974 through 1983. In addition, the deviations of the individual annual seasonal and monthly means from their respective nine year means are presented. The data are the outgoing longwave radiation as observed from the NOAA polar orbiting satellites. The charts exhibit many interesting features, interannual variations and may shed some light on the understanding of the El Nino/Southern Oscillation phenomena.

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## ABSTRACT

This atlas of the outgoing longwave radiation (OLR) contains northern winter monthly and seasonal fields from 40S to 60N over a global belt for the winter (December, January, February) during the decade 1974 through 1983. In addition, the deviations of the individual annual seasonal and monthly means from their respective nine year means are presented. The data are the outgoing longwave radiation as observed from the NOAA polar orbiting satellites. The charts exhibit many interesting features, interannual variations and may shed some light on the understanding of the El Nino/Southern Oscillation phenomena.

## 1. INTRODUCTION

This atlas depicts the northern winter (December, January, February) seasonal and monthly mean OLR field for the nine winters from 1974/1975 to 1982/1983. In addition to the nine-year seasonal and monthly means and the individual annual seasonal and monthly averages the deviations of the individual seasonal and monthly means from their nine-year averages are also presented. The seasonal calculations are based on the months of December, January, and February. To aid in depicting the onset of the winter monsoonal circulations the monthly charts include the November as well as December, January, and February. Details concerning the data set are described in section 2.

Charts of some of these data have been presented in other publications, a partial list is Winston et al. (1979), Lau and Chan (1983), Liebmann and Hartmann (1982). However it was felt that a need existed to gather all the data in one publication and present them on a common grid. The grid chosen to display the OLR was the identical to the mercator grid used by the U.S. Navy's Fleet Numerical Oceanography Center (FNOG) for its Global Band Analysis (GBA). This choice was dictated by the desire to facilitate comparison of the OLR fields with the motion fields presented in volume I of this report.

The OLR data presented here are of interest for two reasons. First, the 1973-1983 decade contains two El Nino/Southern Oscillation (ENSO) events, one occurring in 1976/77 and the other in 1982/83, the latter event is the most intense ENSO events yet observed. Second, the analyses presented here allow the FGGE winter to be placed in a longer term perspective since the FGGE/WMONEX experiment took place in the midst of the decade.

## 2. DATA SOURCES AND HANDLING

### 2.1 OUTGOING LONGWAVE RADIATION DATA

The outgoing longwave radiation (OLR) data presented here are from the NOAA polar orbiting satellite series digitized on a global latitude longitude grid with a grid length of 2.5 degrees. The data are available during an approximately nine year period from June 1974 to June 1983. There is a gap of ten months from March to December 1978 due to satellite malfunction. Details concerning these data were presented in Gruber and Winston (1978). Daily averaged data have been used to alleviate the undesirable effects of the changing equatorial crossing times as different sensing platforms have become operational.

Because of the data gap from March to December 1978 the seasonal means of the OLR data reported here for the winter of 1978/79 are based on the January and February 1979 values only. The data were available on a global 2.5 x 2.5 latitude longitude grid. These data were then interpolated to the U.S. Navy's Global Band Analyses (GBA) mercator grid using a simple bi-linear interpolation. The GBA mercator grid extends from 60N to 40S about the globe. The use of mercator secant projection results in a change in the actual distance between grid points from 140 km at 60N to a maximum value of 280 km at the equator.

### 3. DISCUSSION

#### 3.1 INTRODUCTION

This discussion is not intended to be a comprehensive review of the tremendous amount of data contained in the accompanying figures. Rather the intent is to describe in general terms some of the more obvious general features of interest. It is the same discussion as is in Volume I of this report and is repeated here for completeness.

#### 3.2 EL NINO/SOUTHERN OSCILLATION EVENTS

A perusal of the charts of the seasonal means of OLR (and 200 mb  $\chi$ , in Volume I) clearly show that the dominant center of interannual variability is located in the central Pacific. These fluctuations can be associated with changes driven by the Southern Oscillation.

There are a great many studies in the literature about the global scale aspects of the ENSO events. The particular collection of charts presented here depicts the wintertime OLR fields for two such events occurring in 1976/77 and 1982/83. Liebmann and Hartmann (1982) describe the anomalous (based on a three year average) patterns of OLR for the 1976/77 event. They show the increase in convection activity over Indonesia shifts eastward after the sea-surface temperature (SST) in the east Pacific becomes anomalously warm. The South Pacific convergence zone (SPCZ) intensifies and moves eastward but does not reach its intensity until more than a year after the SST increases occur. Lau et al. (1983) consider the anomalous OLR,  $\psi$  and  $\chi$  patterns for both the 76/77 and 82/83 ENSO events using the same data as presented here (and in volume I). They concluded that the circulation changes associated with each individual ENSO event can be

quite different, but that the anomalous OLR patterns and circulation features within each event were consistent. They showed that prior to the ENSO of 1976/77 the equatorial central Pacific convection was strongly suppressed for at least a two year period prior to December 1975. The seasonal data of 1976/77 and 1977/78 evince a dramatic reversal in the  $\chi$  pattern in the eastern Pacific.

### 3.3 DECADE OVERVIEW

If one examines the seasonal means of  $\chi$  and OLR it becomes apparent that there is a shift in the equatorial Pacific about the middle of the decade. Figure I is a time series of the deviations from the ten-year mean of the winter season  $\chi$  field averaged over the region from 175E to 140W and 10N to 10S. The figure indicates two regimes, one going from 1973/75 to 1976/77, the other from 1977/78 to 1982/83. The former has relatively low values of  $\chi$ , the latter relatively high values. Figure I also contains a time series of the deviations from the nine-year mean of the winter season OLR (winter 1973/74 not available) averaged over the same region as the  $\chi$  values. Negative values indicate relatively decreased OLR which can be construed to mean decreased convection in the tropics. Figure I demonstrates a negative correlation, which implies that the independently derived data sets are consistent on the seasonal time scale. Note that the OLR values are plotted on an inverse scale from the  $\chi$  graph. This also indicates that the FGGE winter (1978/79) is more characteristic of the regime in the latter half of the decade and care must be taken extrapolating inferences drawn from the FGGE data to other years.

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## FIGURES

Figure I

Time series of the deviations of the seasonal means of  $\chi$  and OLR from their respective ten- and nine-year seasonal means. The values are areal averages over the region bounded by 10N to 10S and 175E to 140W. The  $\chi$  values are represented by the solid line, the OLR values by the dashed line. Note that the OLR ordinate scale (on the left hand side of the graph) is reversed from that of the  $\chi$  ordinate. The ten-year mean value of  $\chi$  for the region is  $4.6 \times 10^6 \text{ m}^2 \text{ s}^{-1}$ . The nine-year mean of OLR for the region is  $234 \text{ Wm}^{-2}$ .

Figure A1

Nine year winter season mean of outgoing longwave radiation (OLR). The data are for the winters from 1974/75 to 1982/83. Winter is defined as December, January, and February. Because of equipment malfunctions the data for December 1978 is not available and the data for January and February 1979 are used for the 1978/79 season. Contour interval is  $25 \text{ Wm}^{-2}$ . Regions with values less than  $225 \text{ Wm}^{-2}$  are stippled. The grid intervals of the FNOC Global Band Analysis mercator grid are shown on the left hand side and bottom of each figure. The longitude grid is marked every  $30^\circ$  from the Greenwich meridian on the extreme left and the latitude is marked every  $10^\circ$  from 40S at the bottom of the figure.

## Figures B1 - B18

Individual winter season mean and deviation outgoing longwave radiation for the winters from 1974/75 to 1982/83. The deviations are differences from the nine-year seasonal mean (Fig. A1). The figures are marked with the year corresponding to the year of the January and February of the winter. For the mean fields the contour interval is  $25 \text{ Wm}^{-2}$  with values less than  $225 \text{ Wm}^{-2}$  stippled. For the deviation fields the contour interval is  $10 \text{ Wm}^{-2}$  with absolute values greater than  $20 \text{ Wm}^{-2}$  stippled. On the deviation plots contours with negative values are dashed, those with positive values and the zero line are solid.

## Figure C1 - C4

Nine-year (1973 - 1983) monthly mean outgoing longwave radiation. The months displayed are November, December, January and February. Because of equipment malfunctions the data for November 1978 and December 1978 are not available. Contour interval is  $25 \text{ Wm}^{-2}$ . Region with values less than  $225 \text{ Wm}^{-2}$  are stippled.



# Figures D1 - D68

Individual monthly mean and deviation of outgoing longwave radiation for the months from November 1974 to February 1983. The deviations are differences from the nine-year monthly means (Figs. C1 and C4). The months displayed are November, December, January, and February. Because of equipment malfunctions the data for November 1978 and December 1978 are not available. For the mean fields the contour interval is  $25 \text{ Wm}^{-2}$  with values less than  $225 \text{ Wm}^{-2}$  stippled. For the deviation fields the contour interval is  $10 \text{ Wm}^{-2}$  with absolute values greater than  $20 \text{ Wm}^{-2}$  stippled. On the deviation plots contours with negative values are dashed, those with positive values and the zero line are solid.

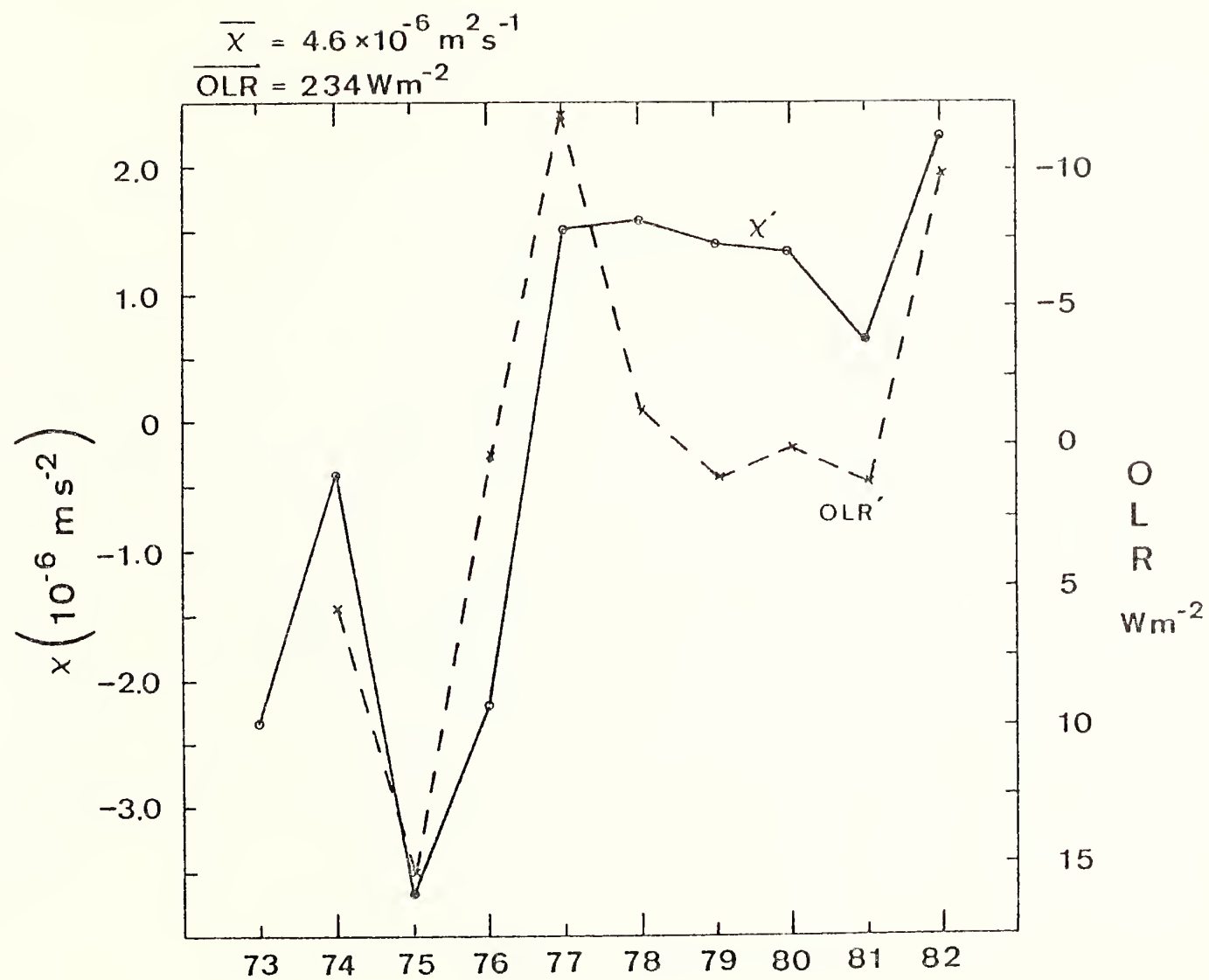
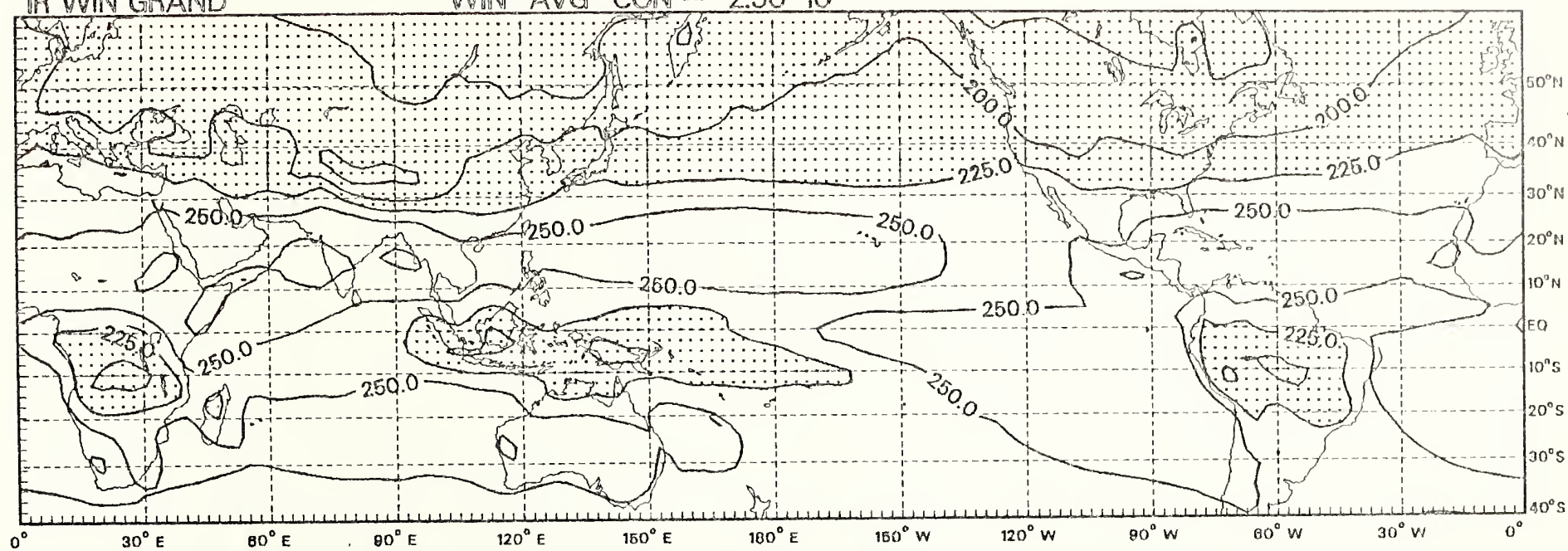


Figure I

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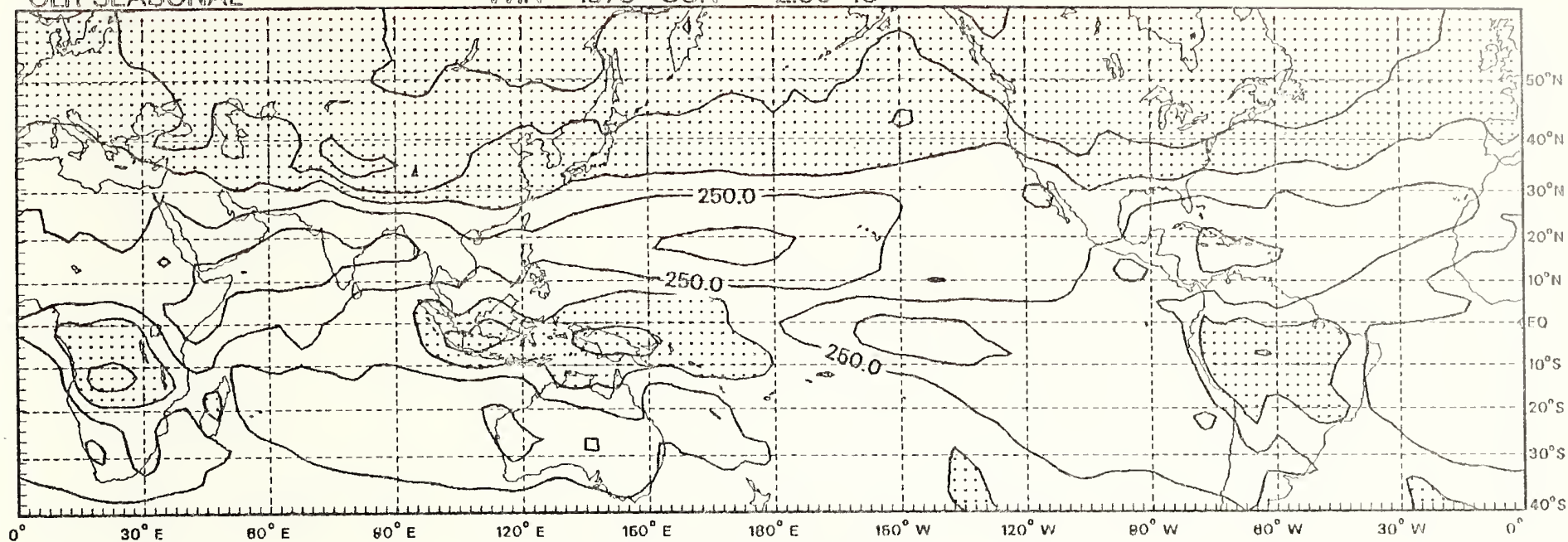
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OLR SEASONAL

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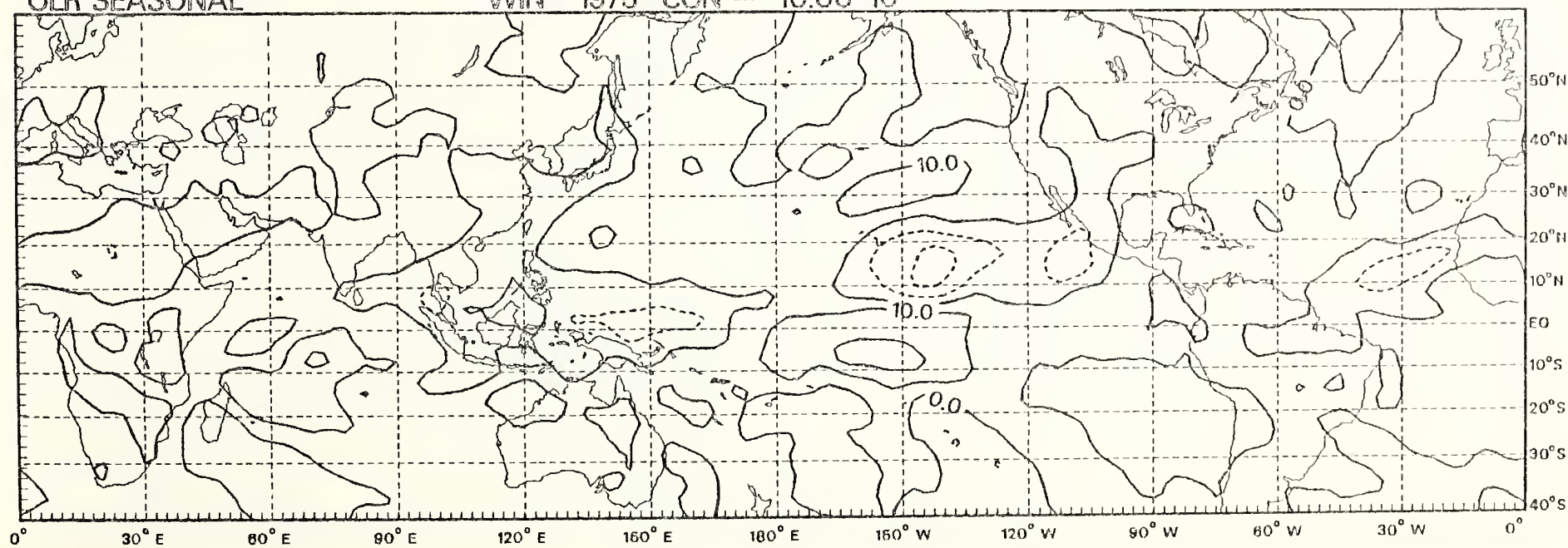
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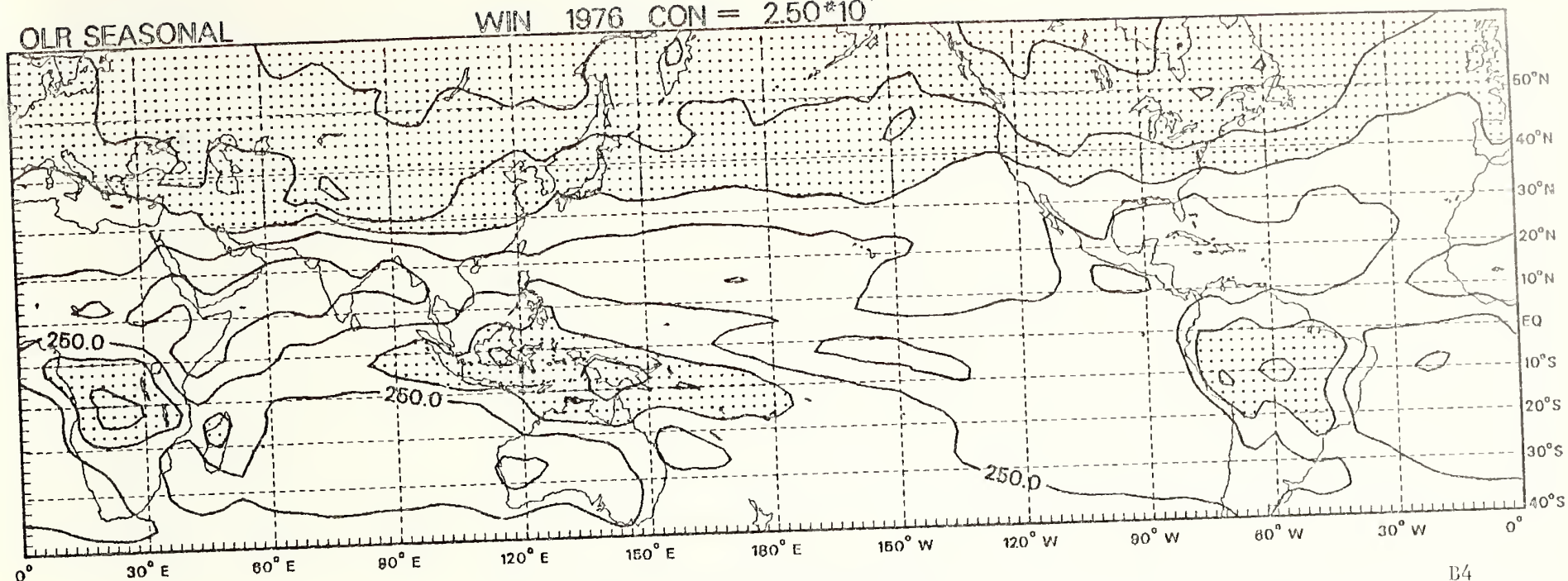
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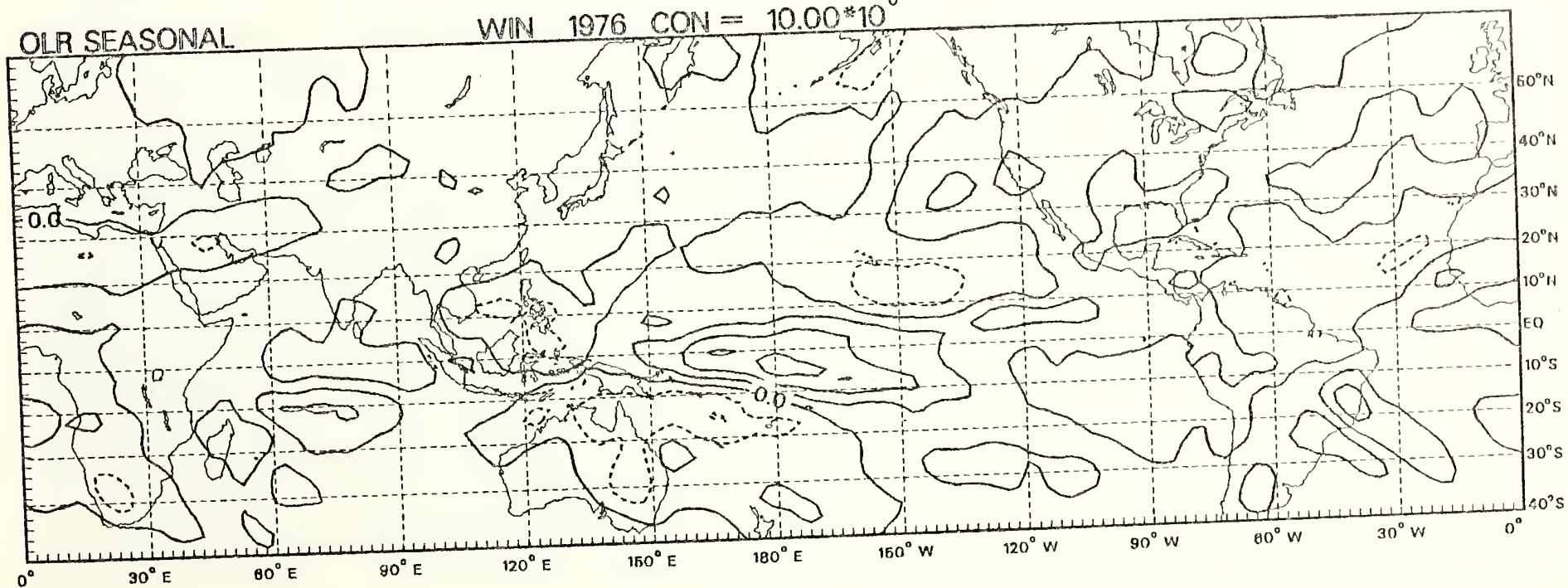


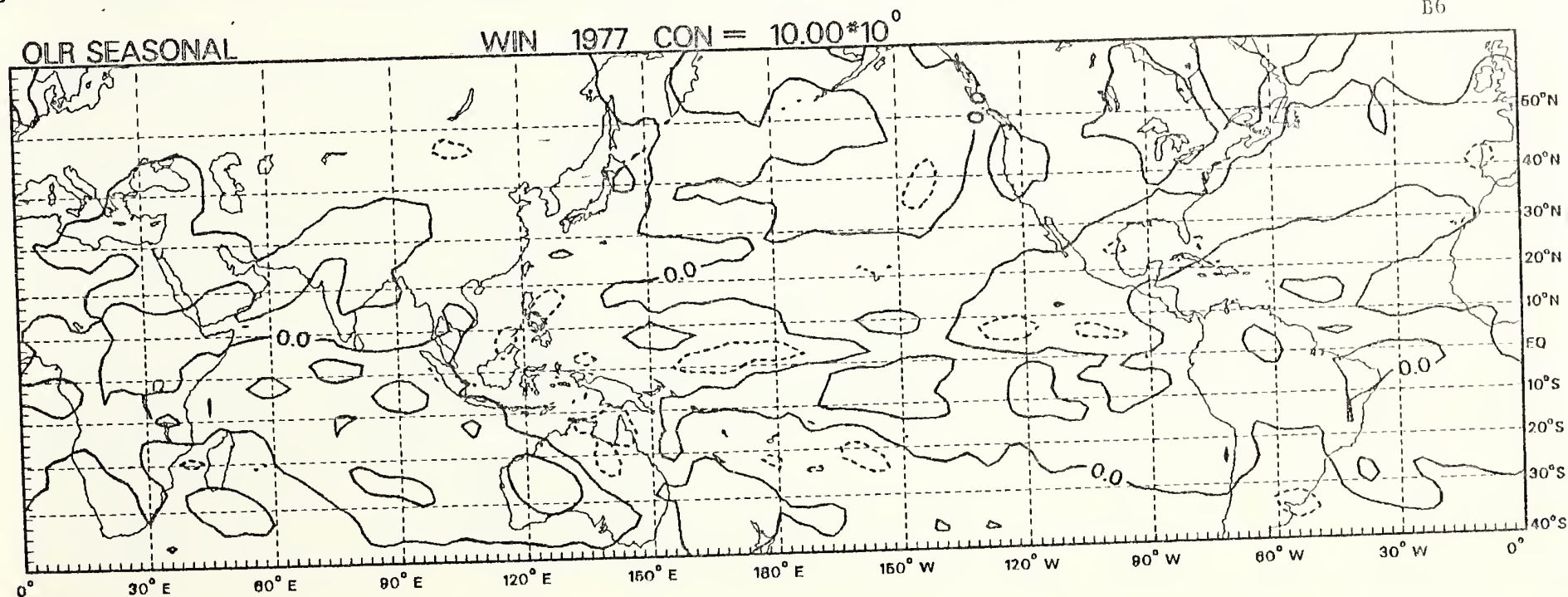
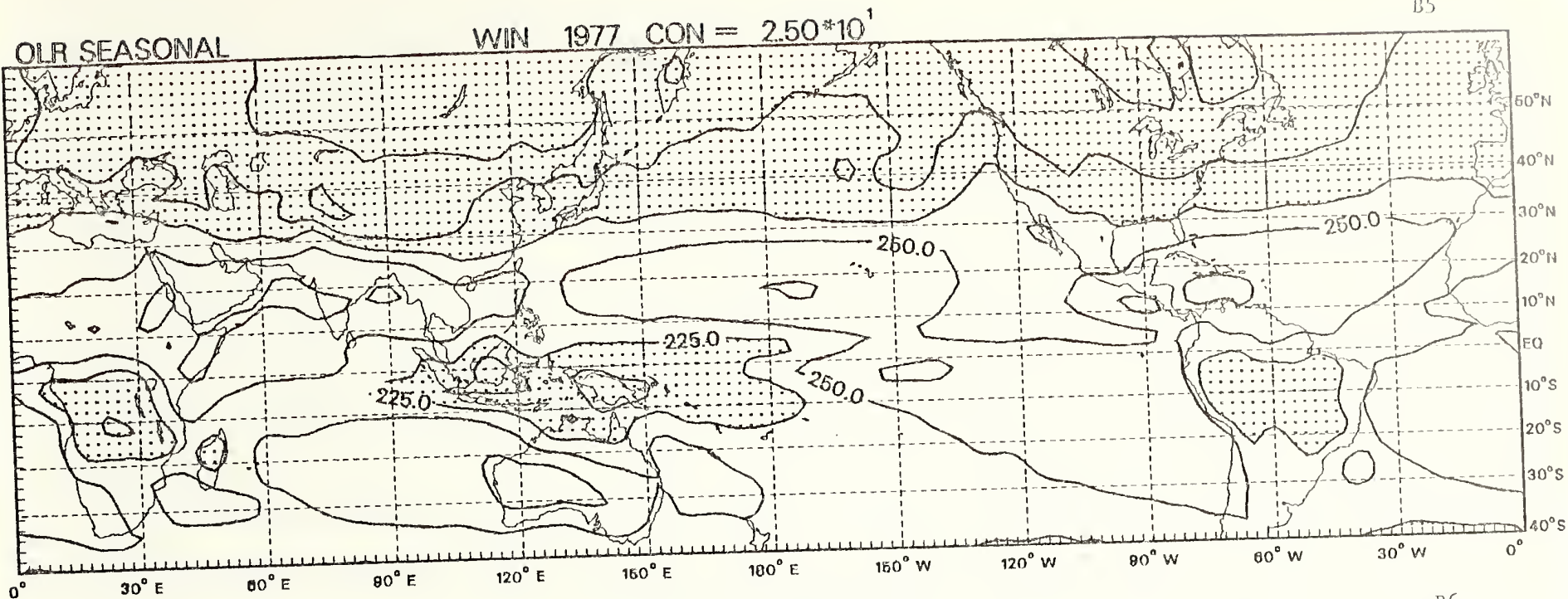
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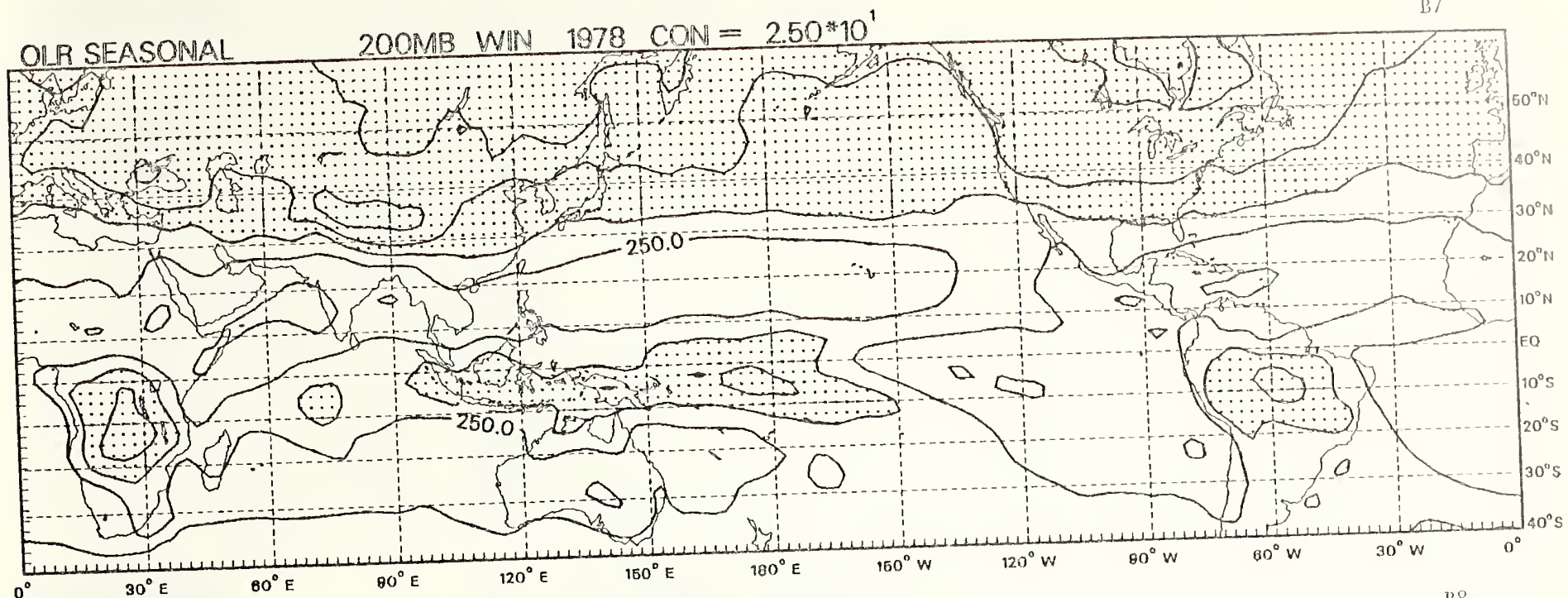
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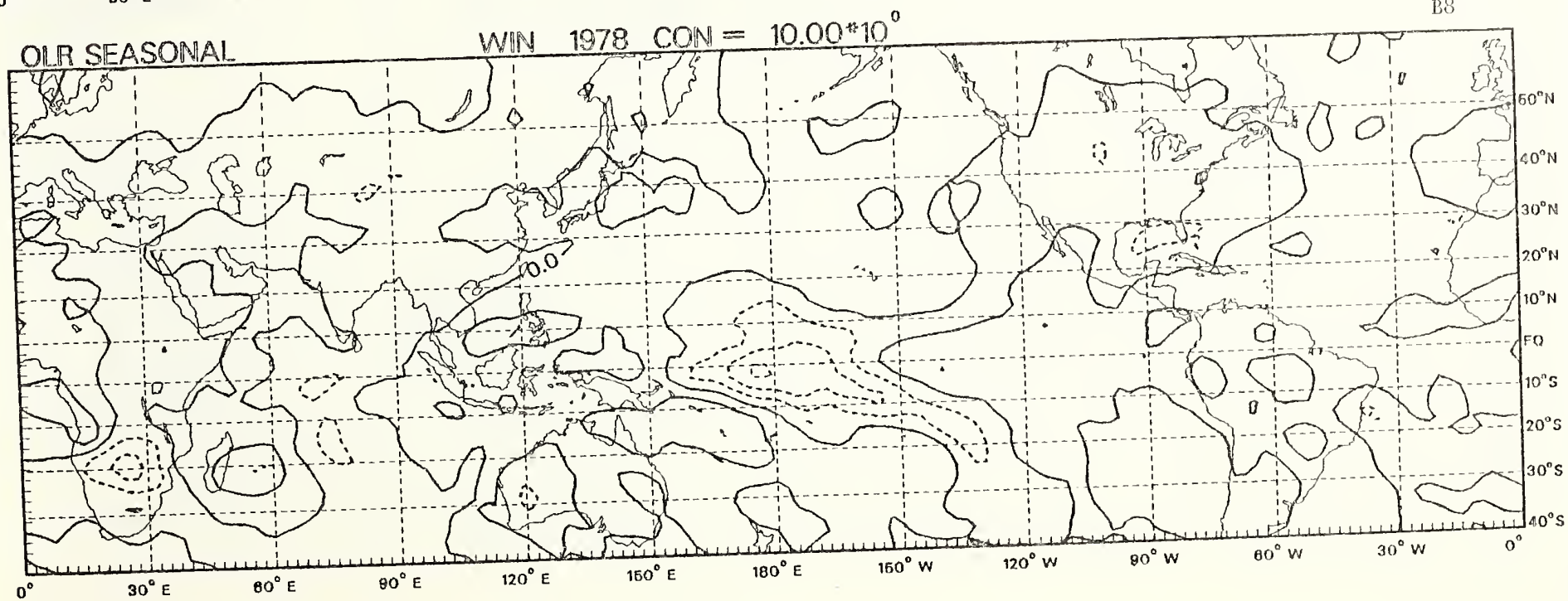




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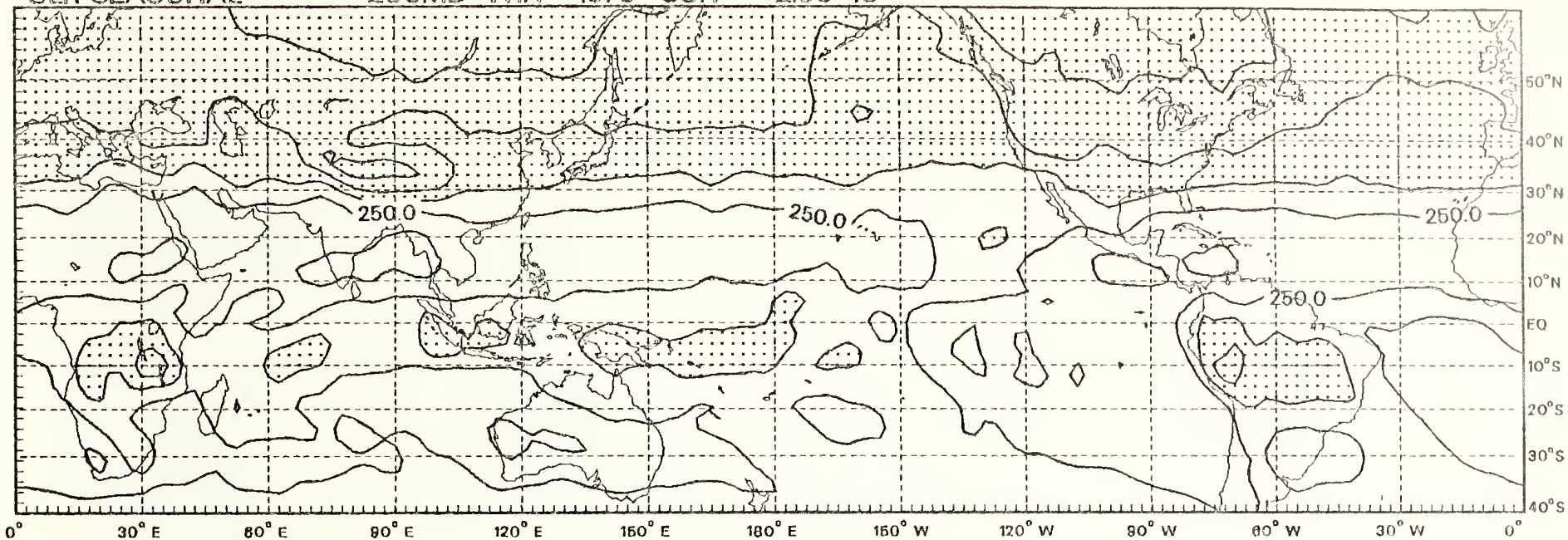


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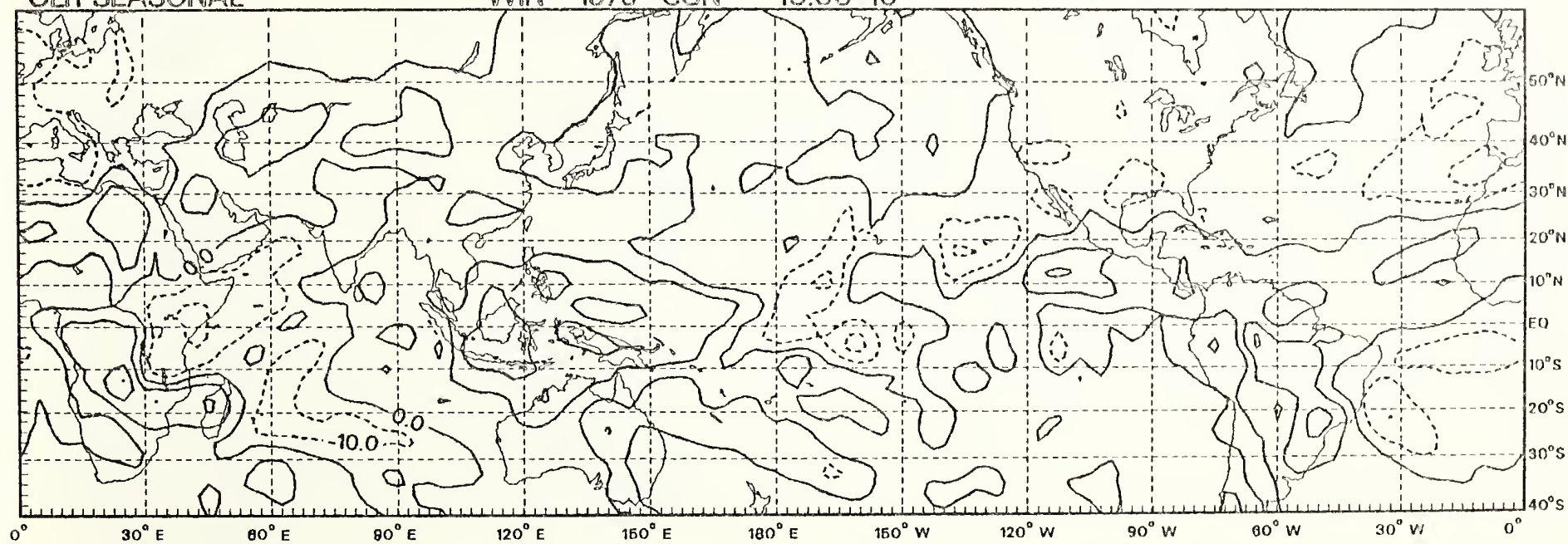
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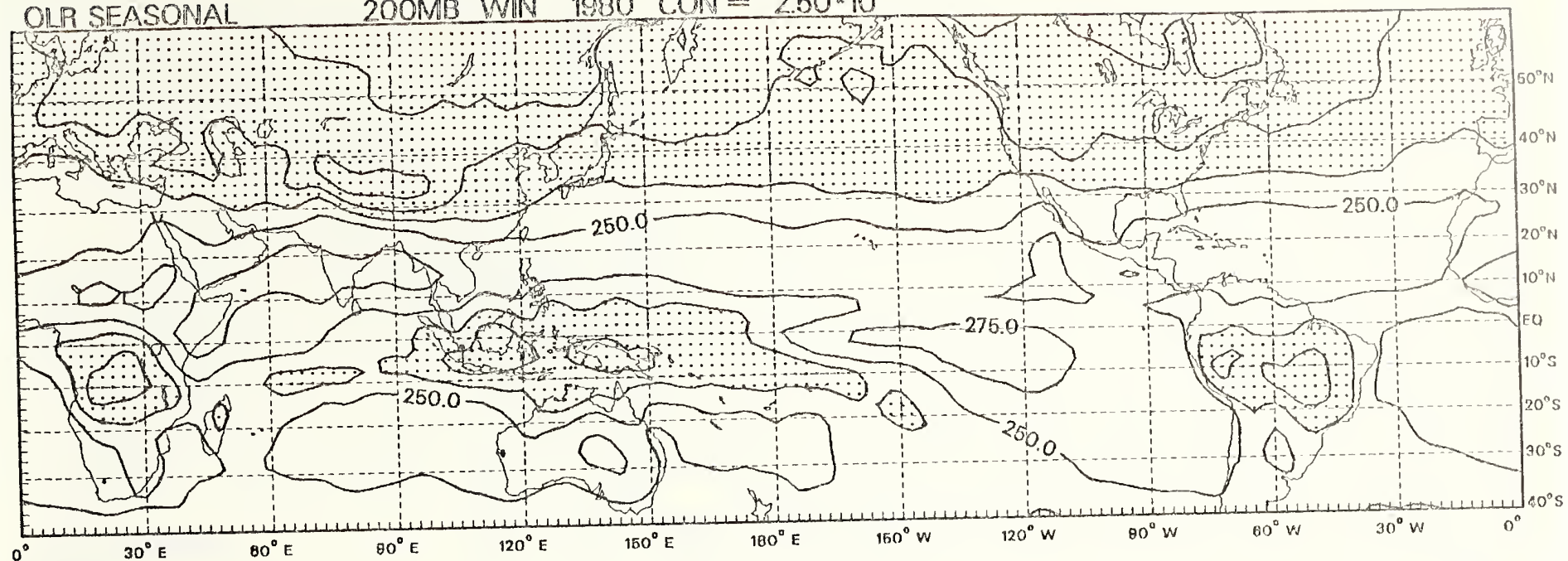
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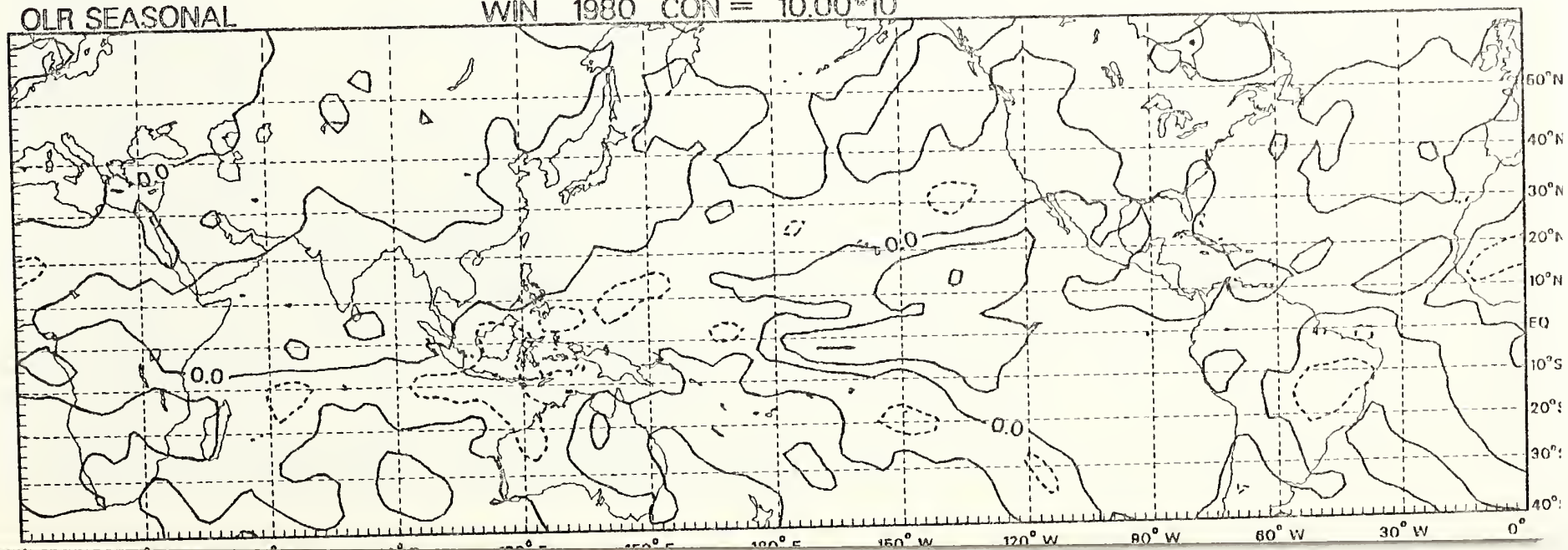
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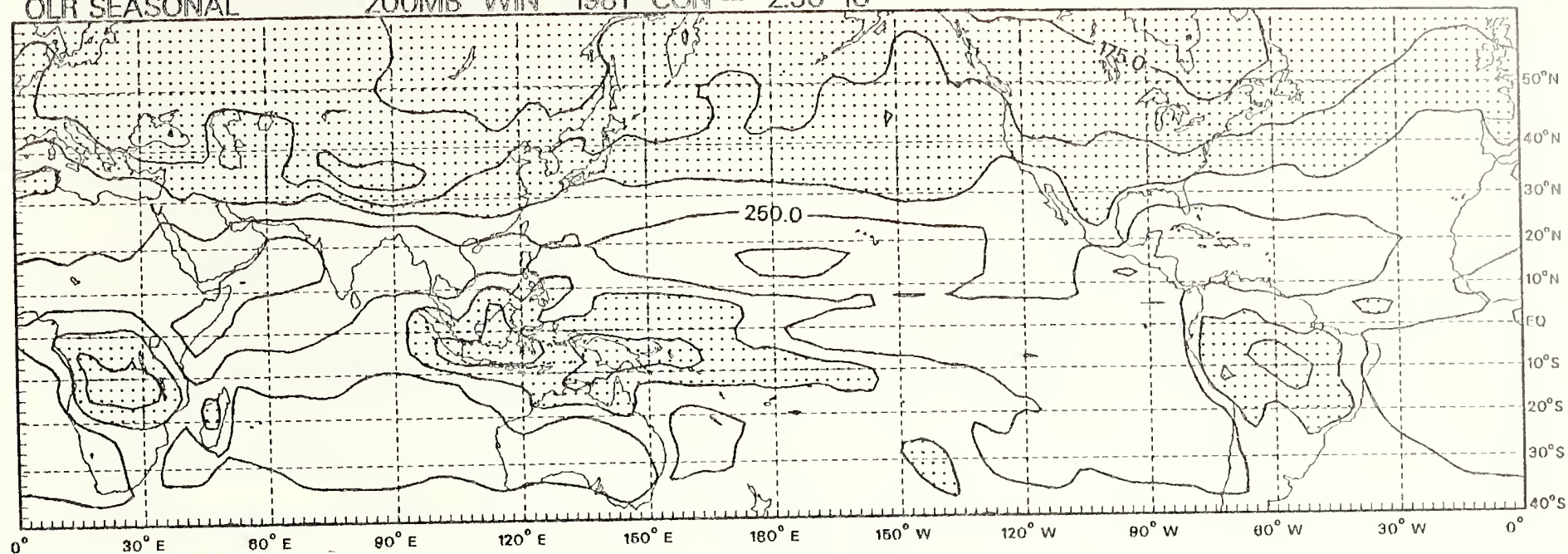
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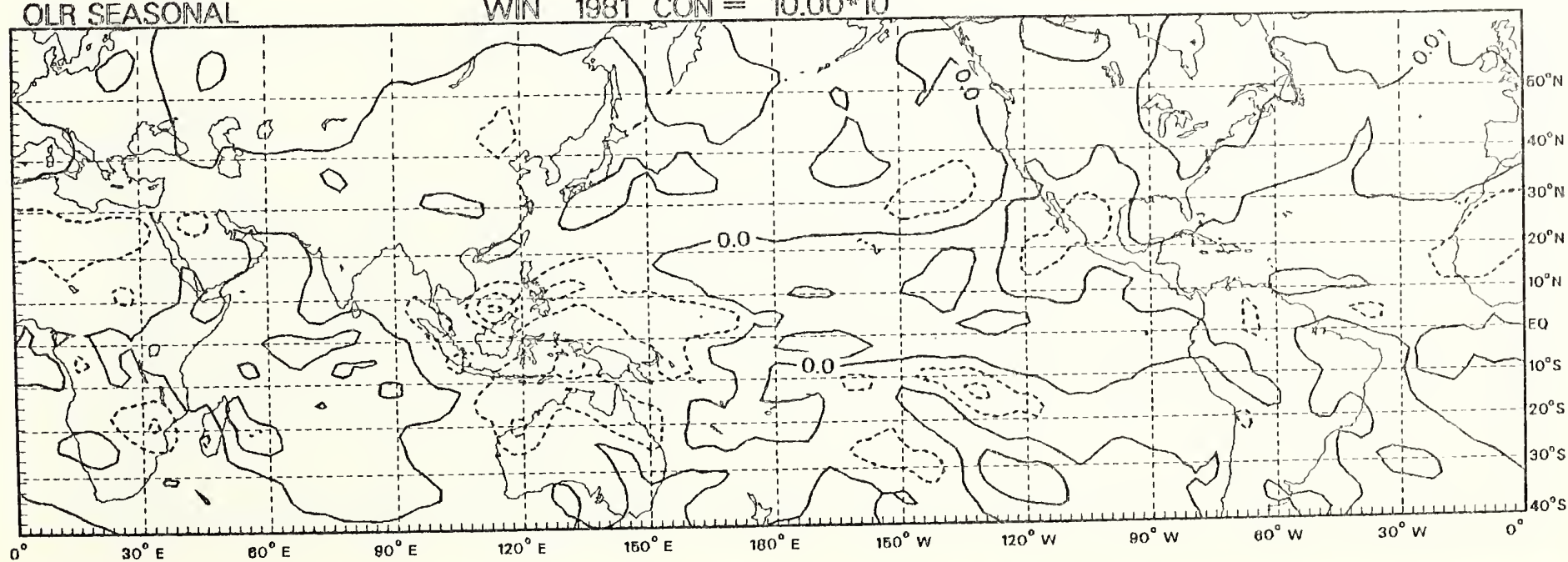
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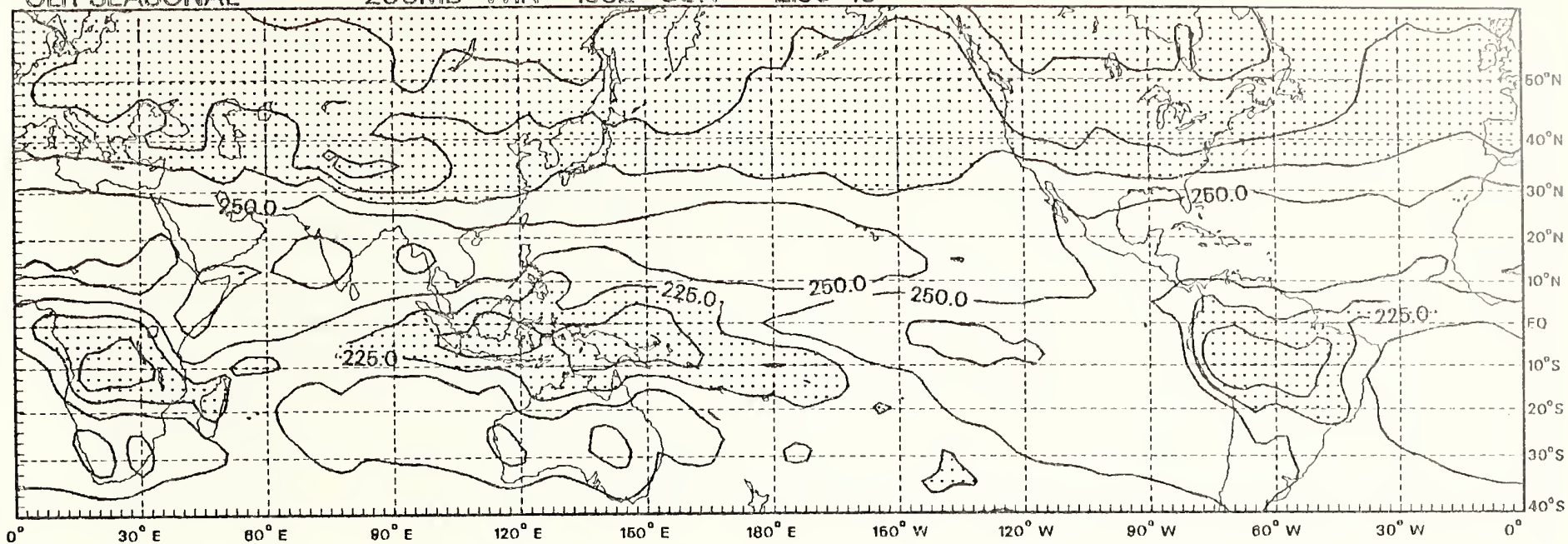




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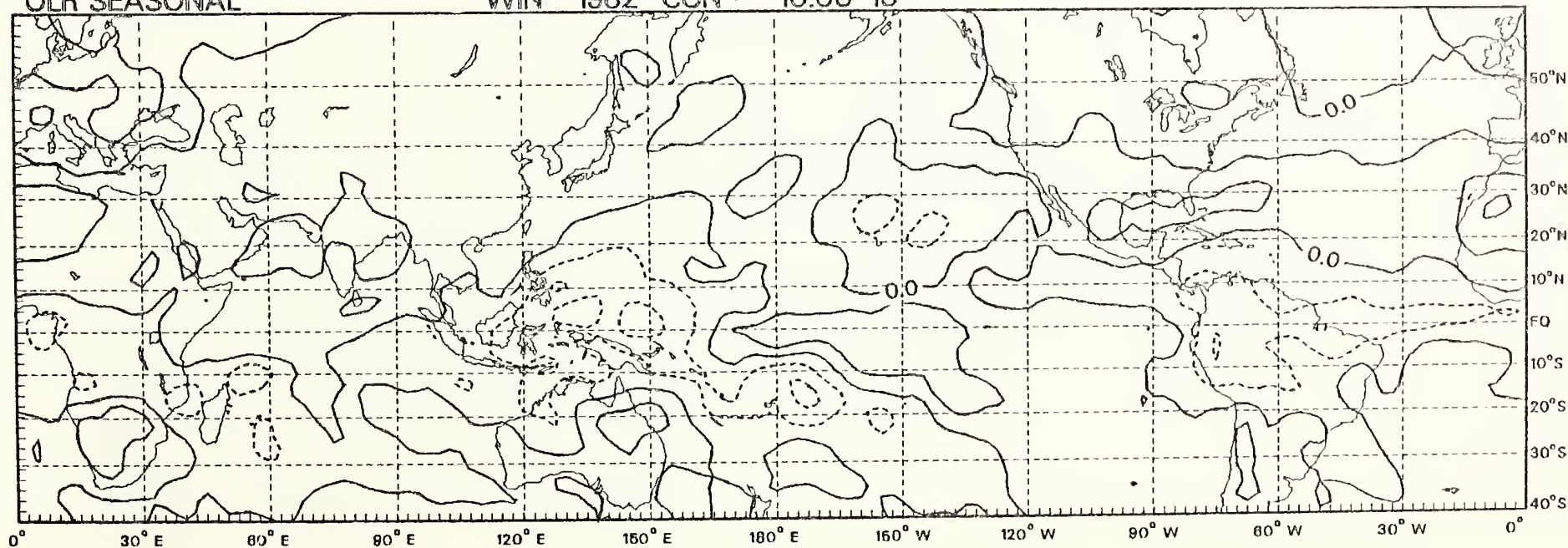
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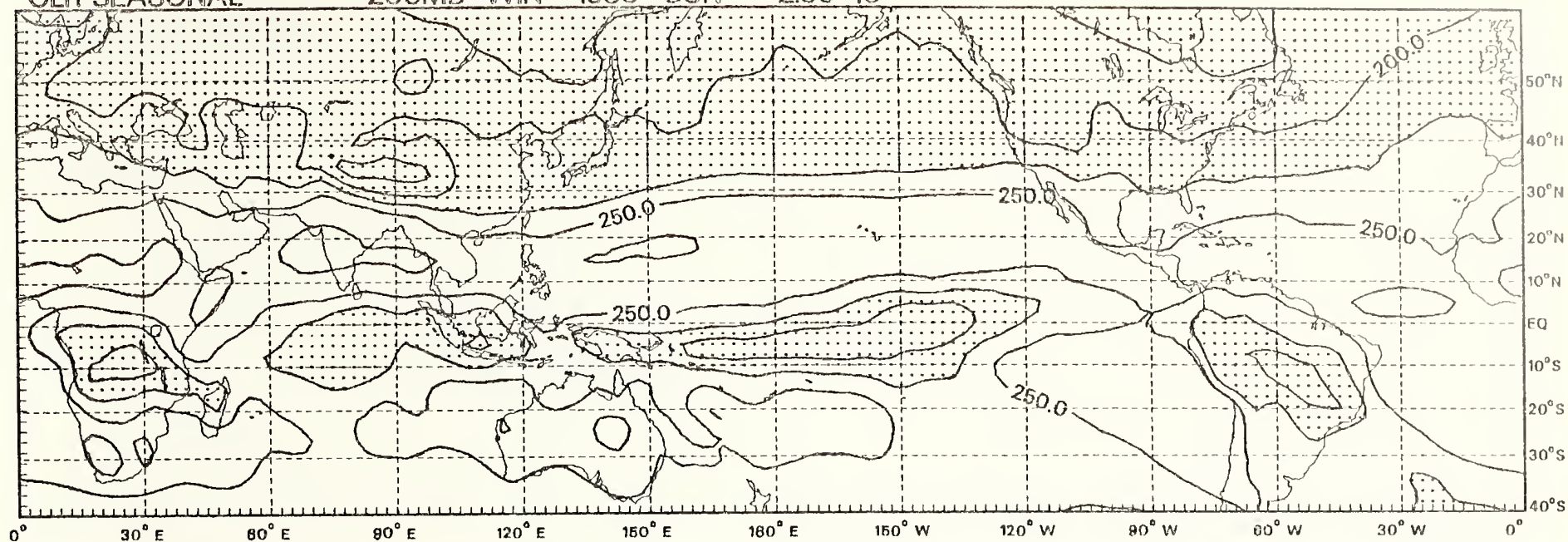
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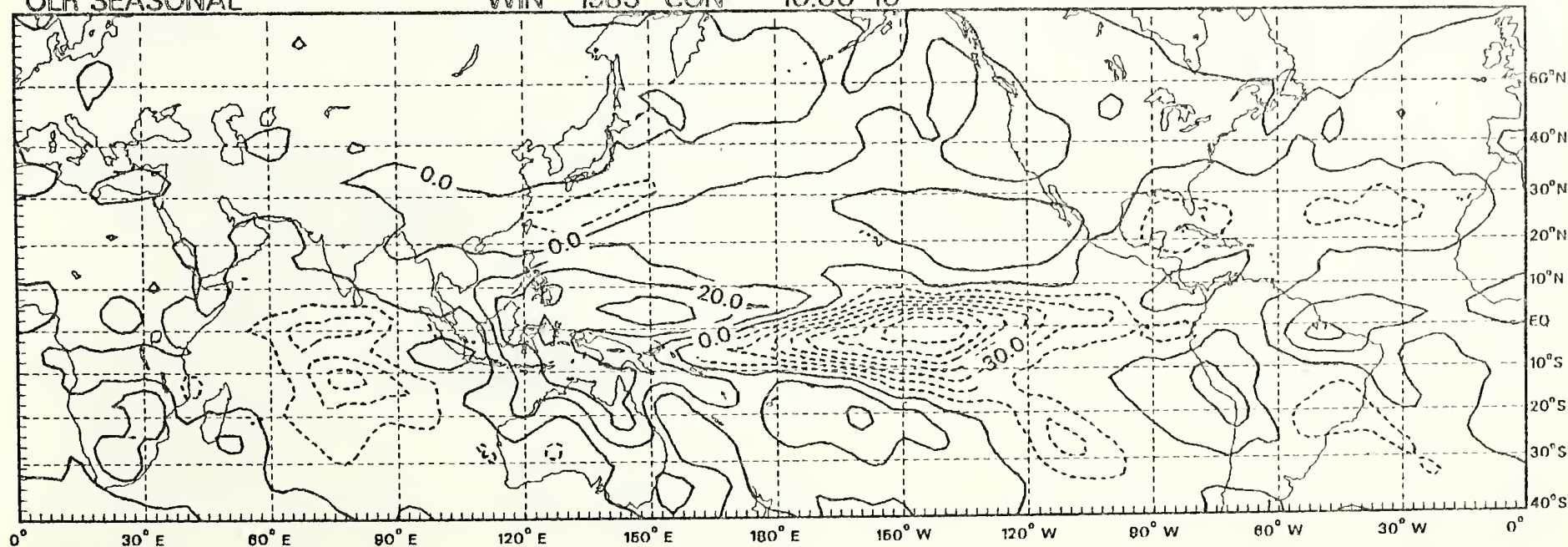
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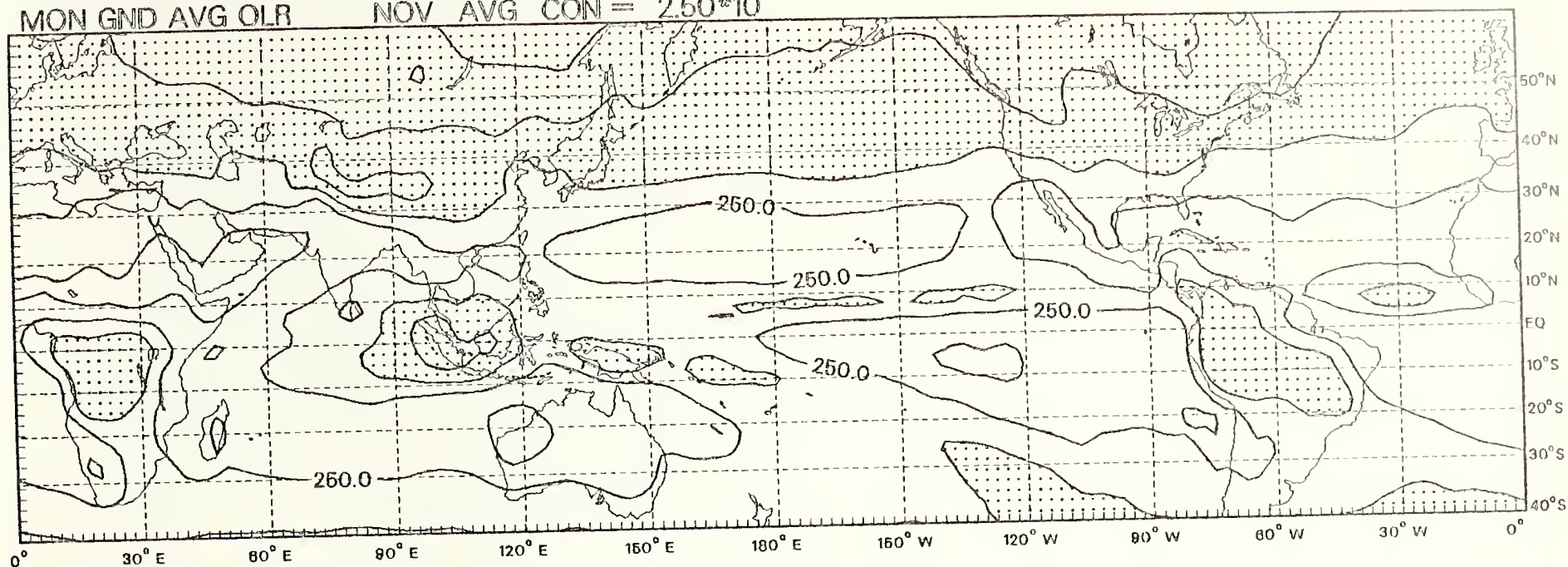
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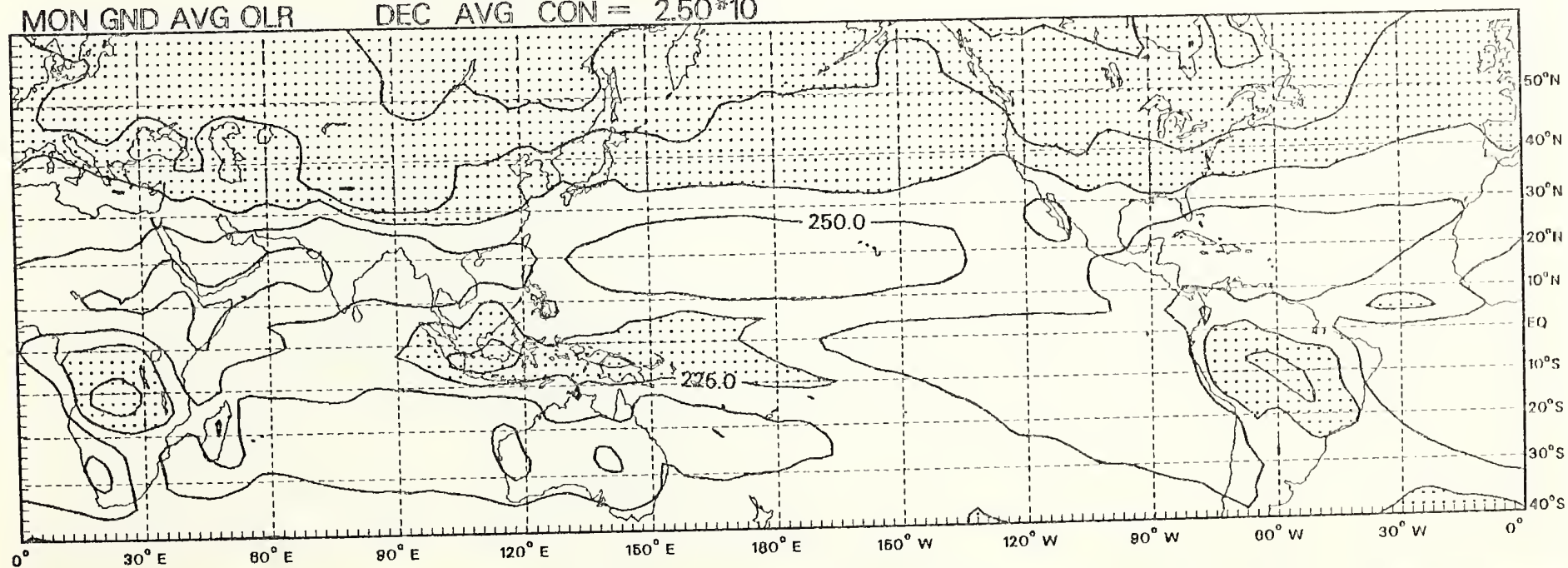
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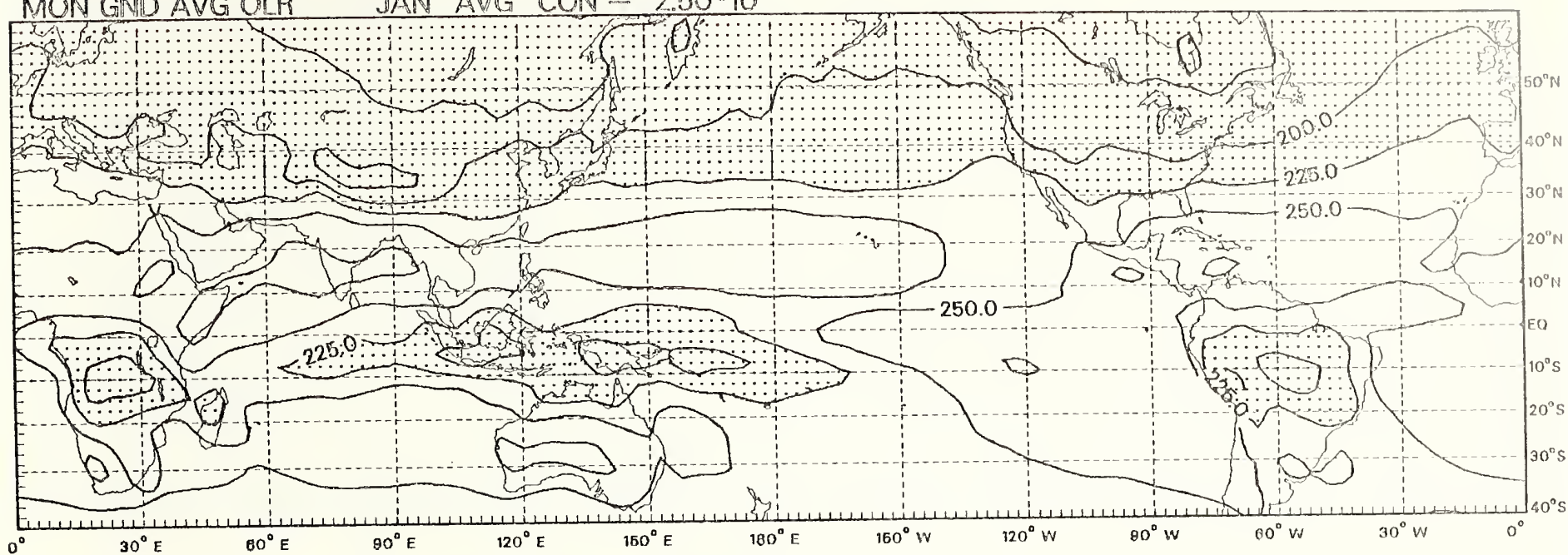
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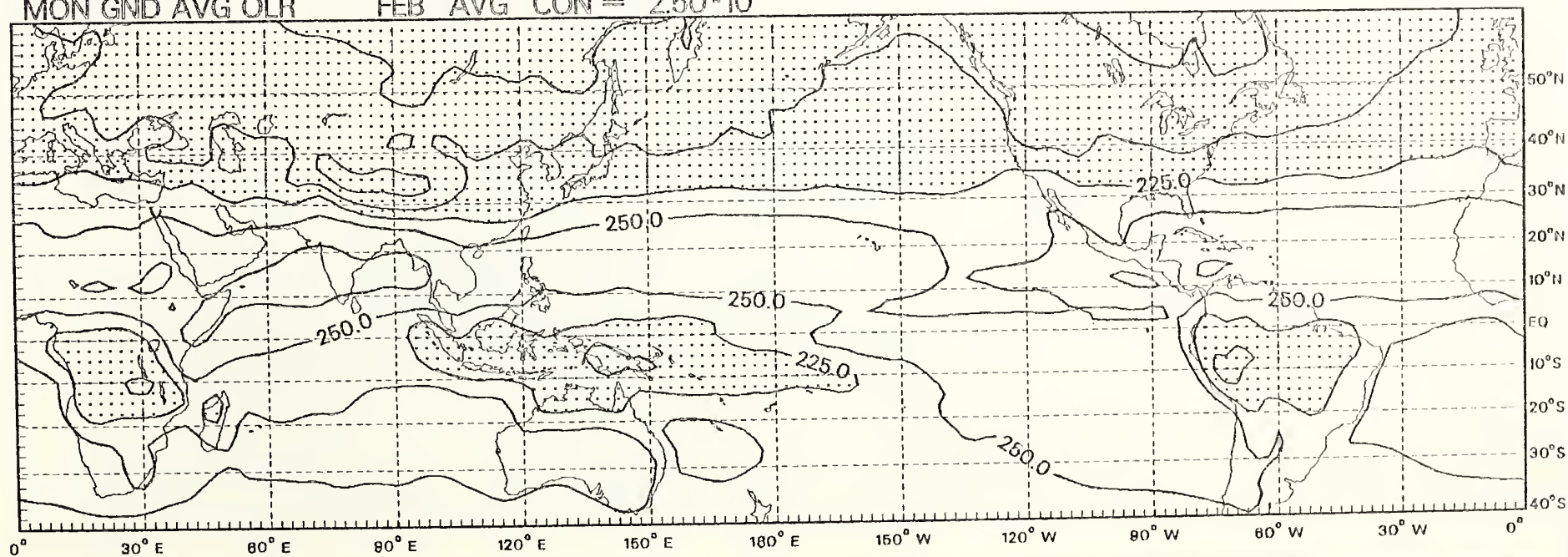
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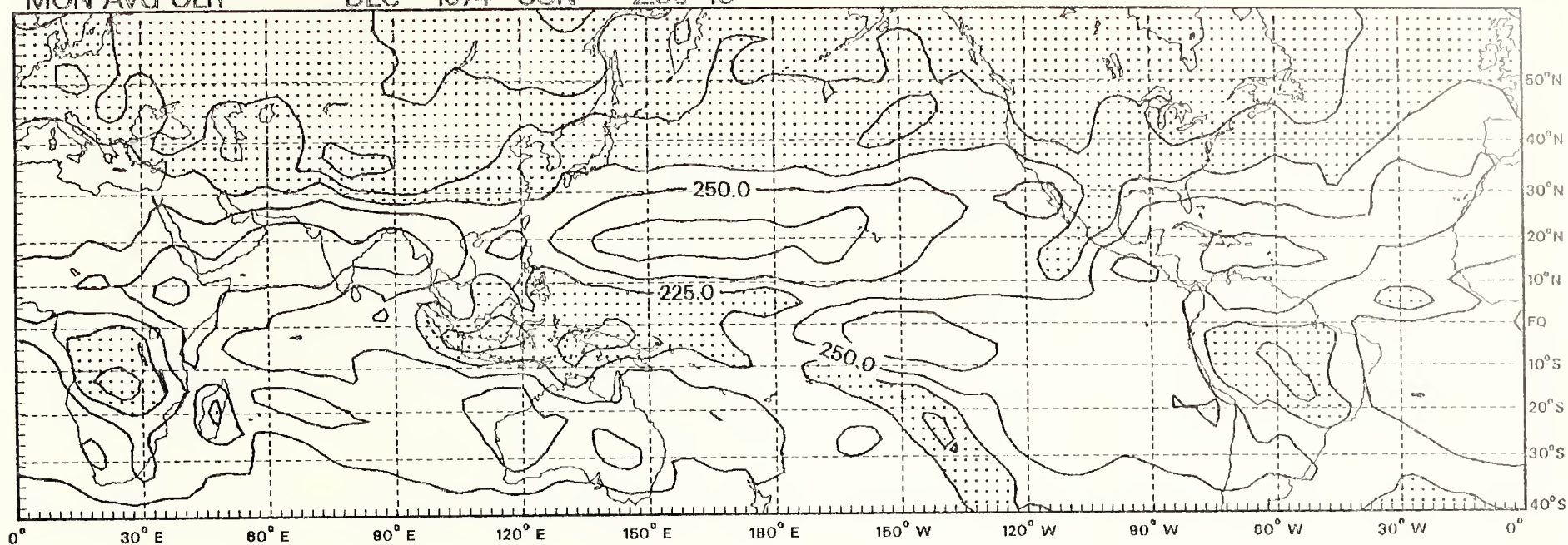
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MON AVG OLR

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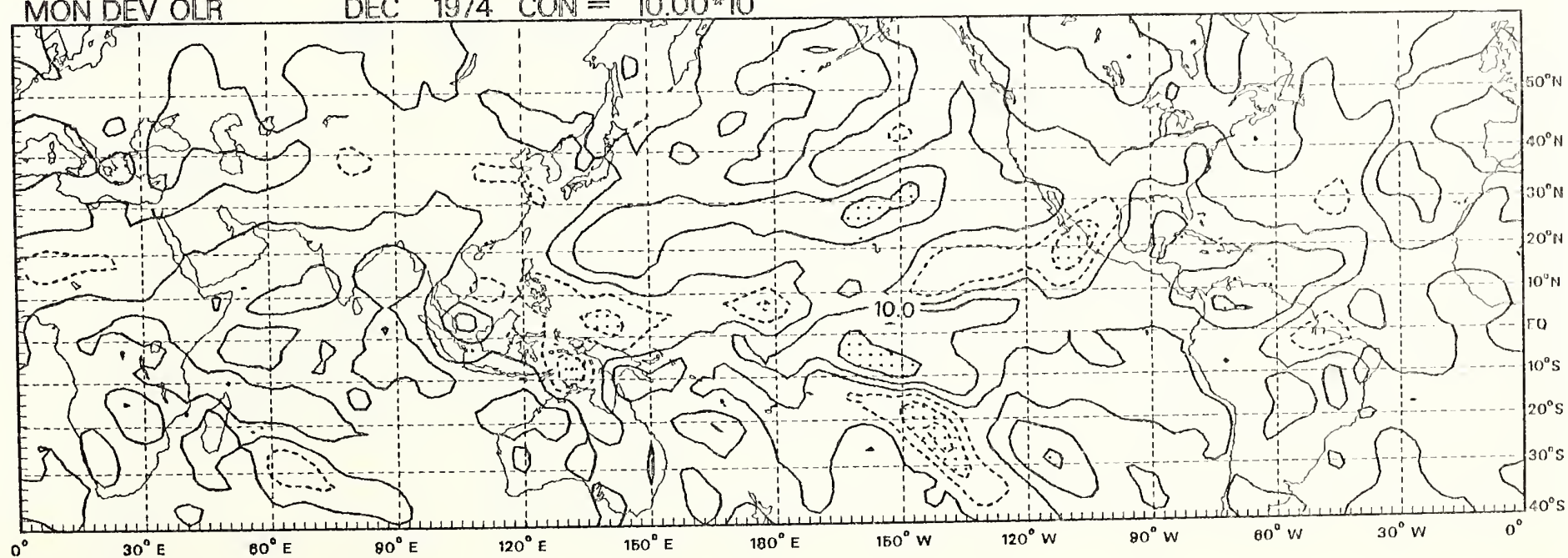
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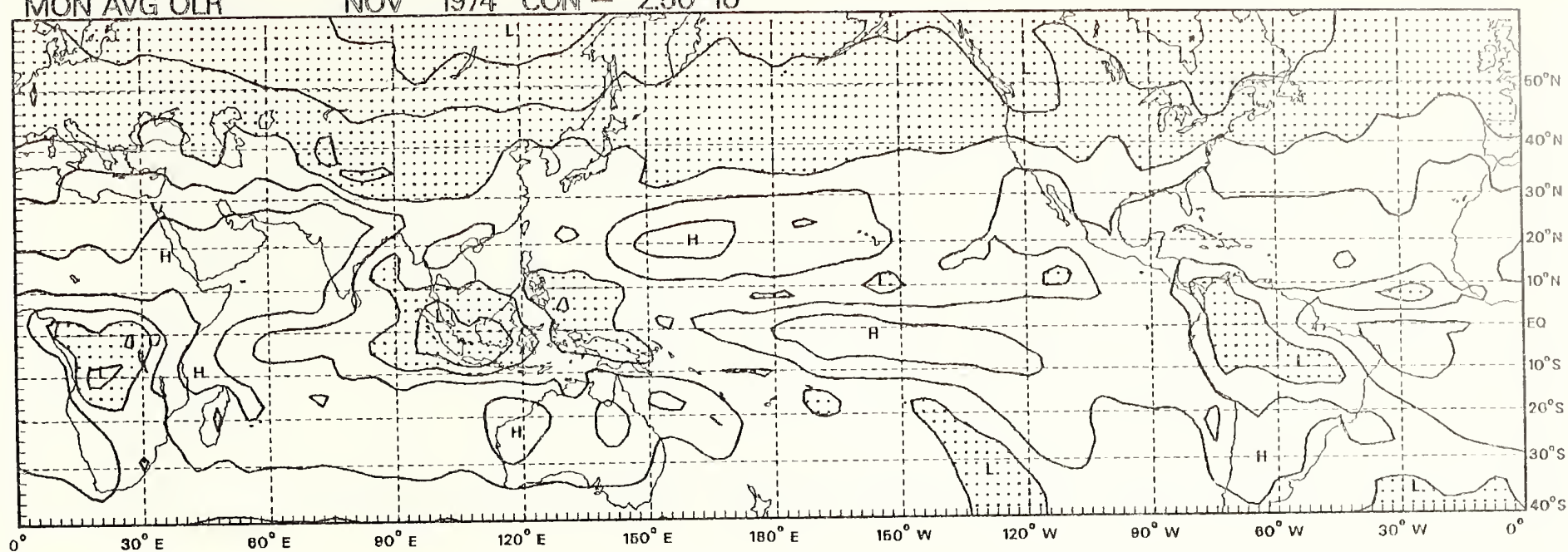
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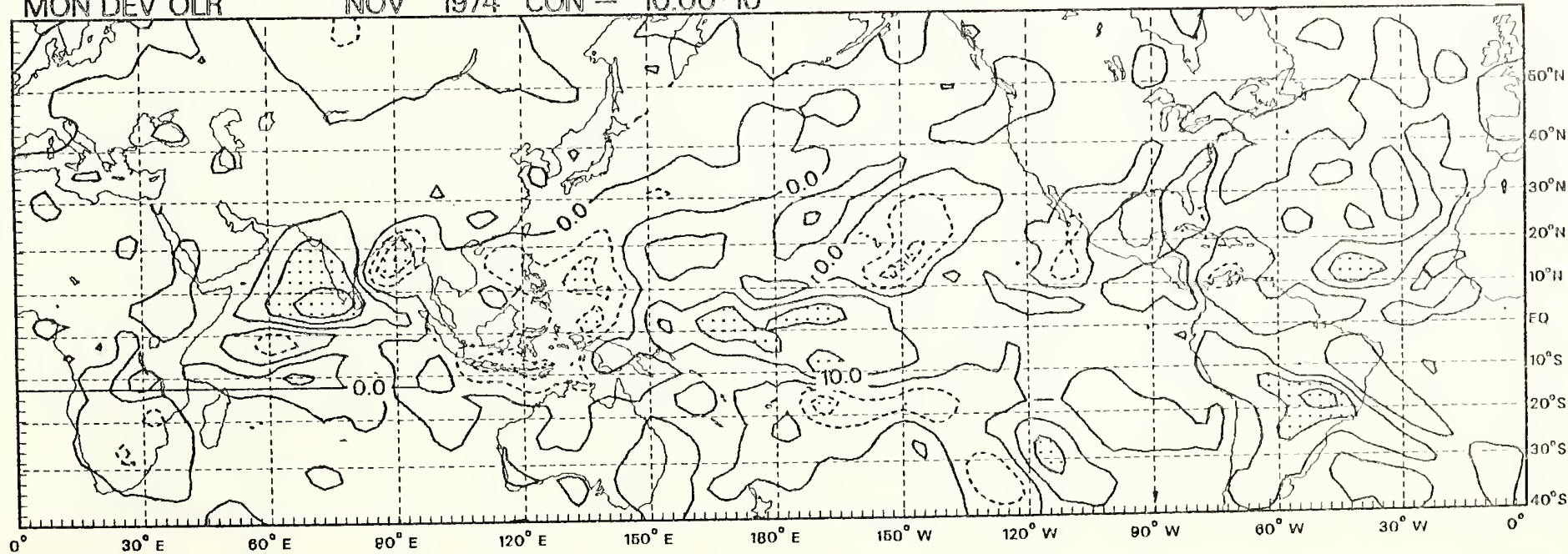
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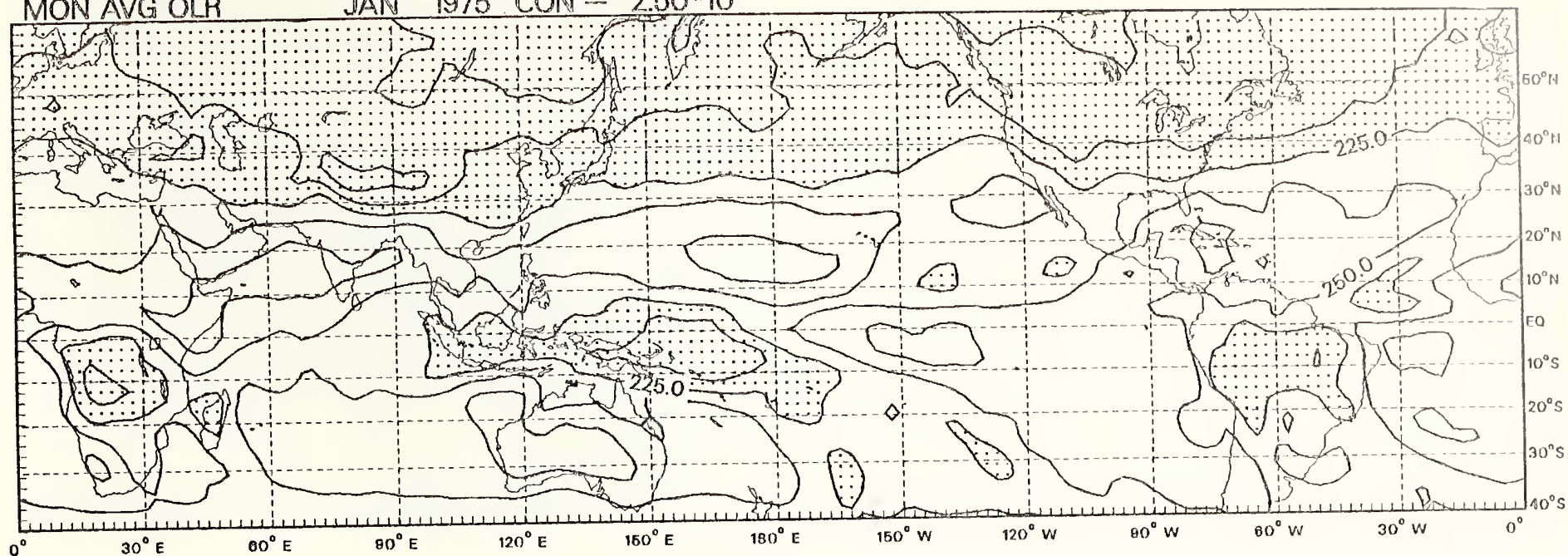
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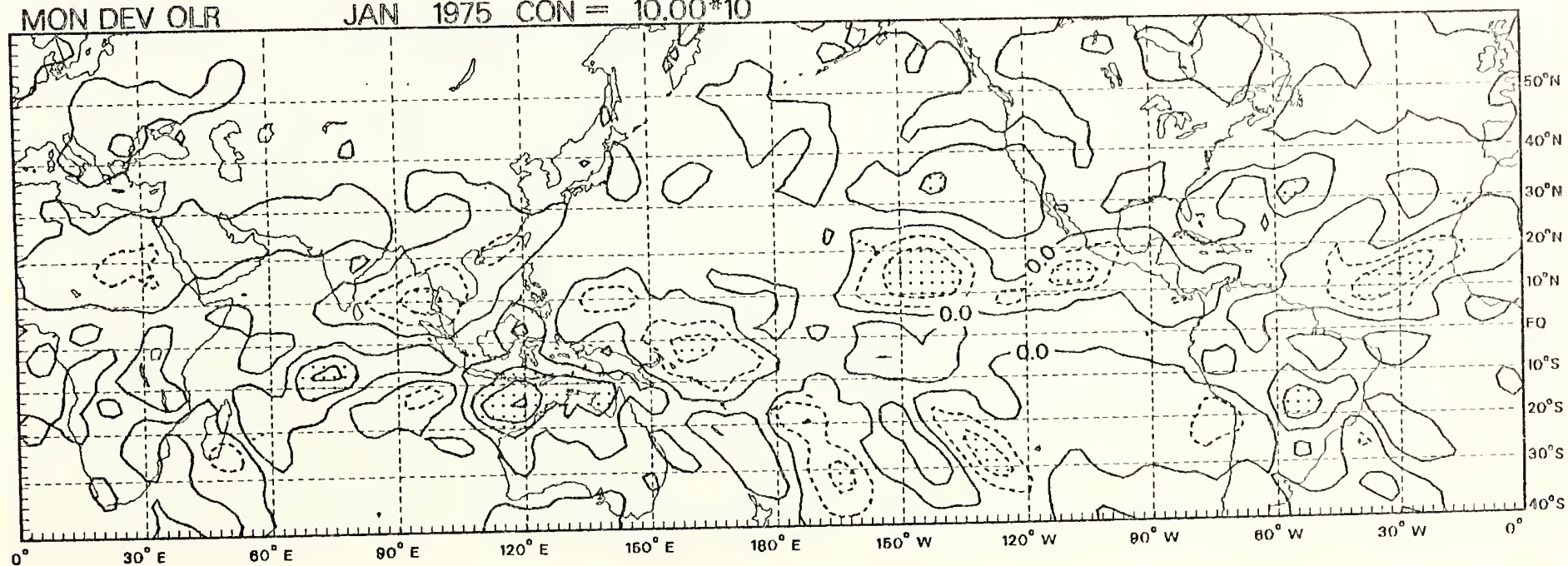
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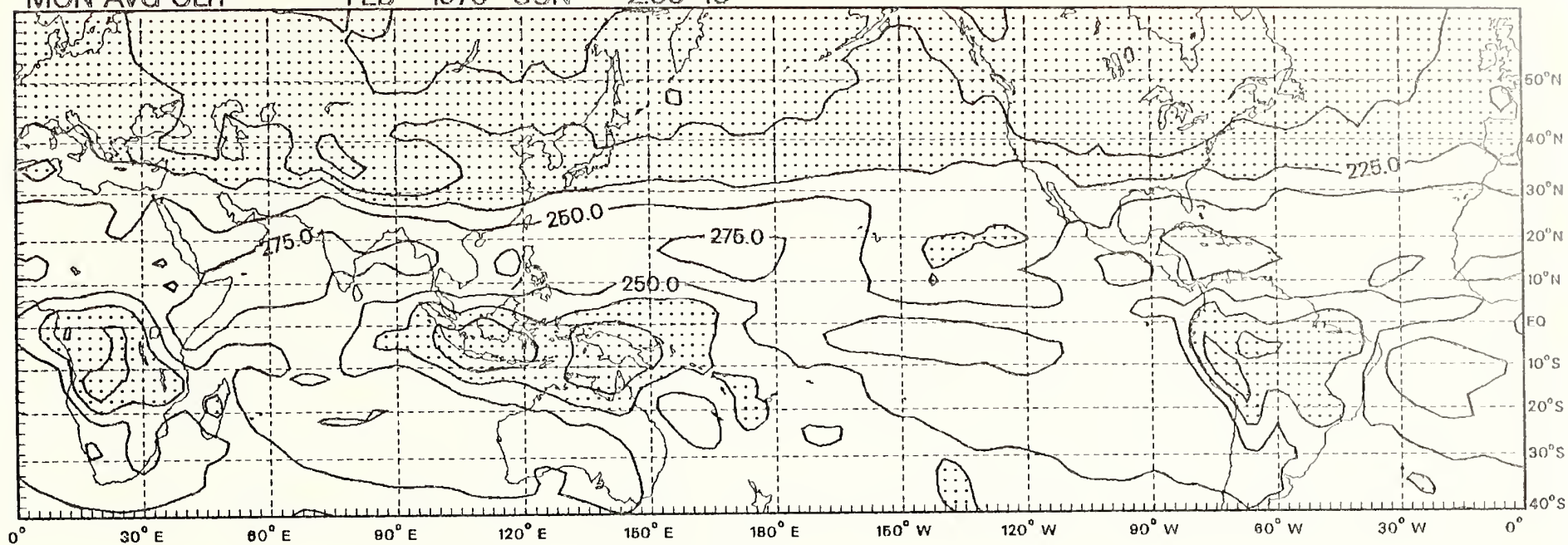
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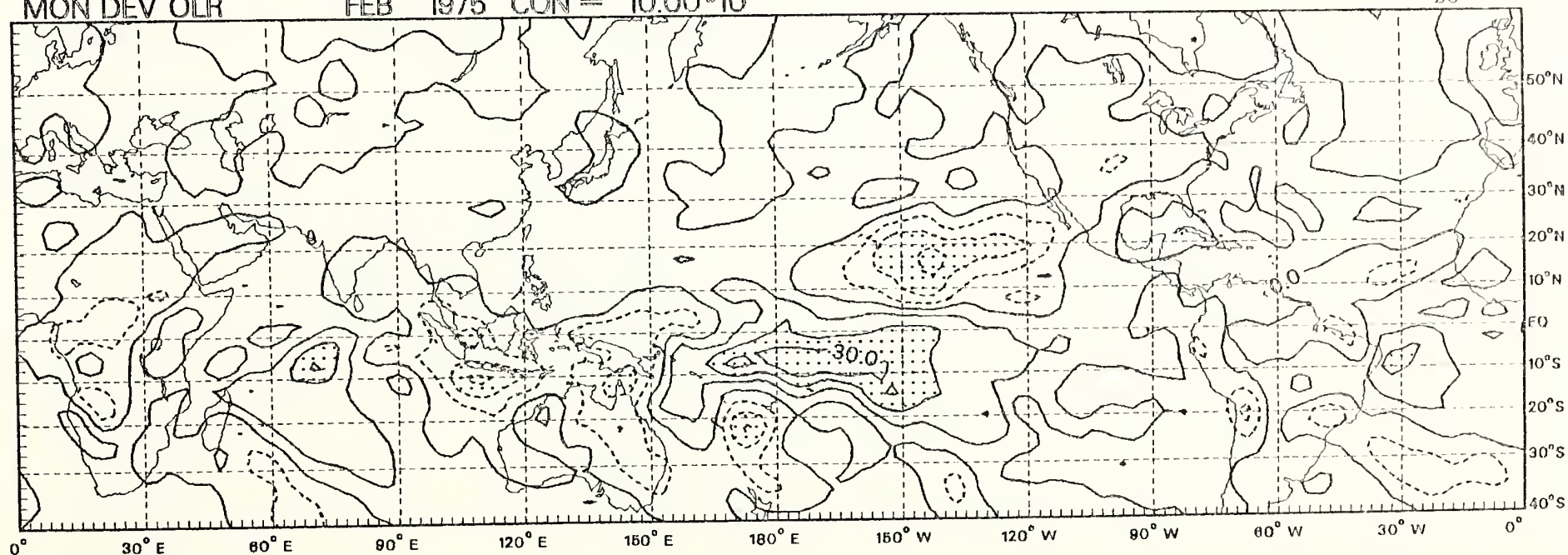
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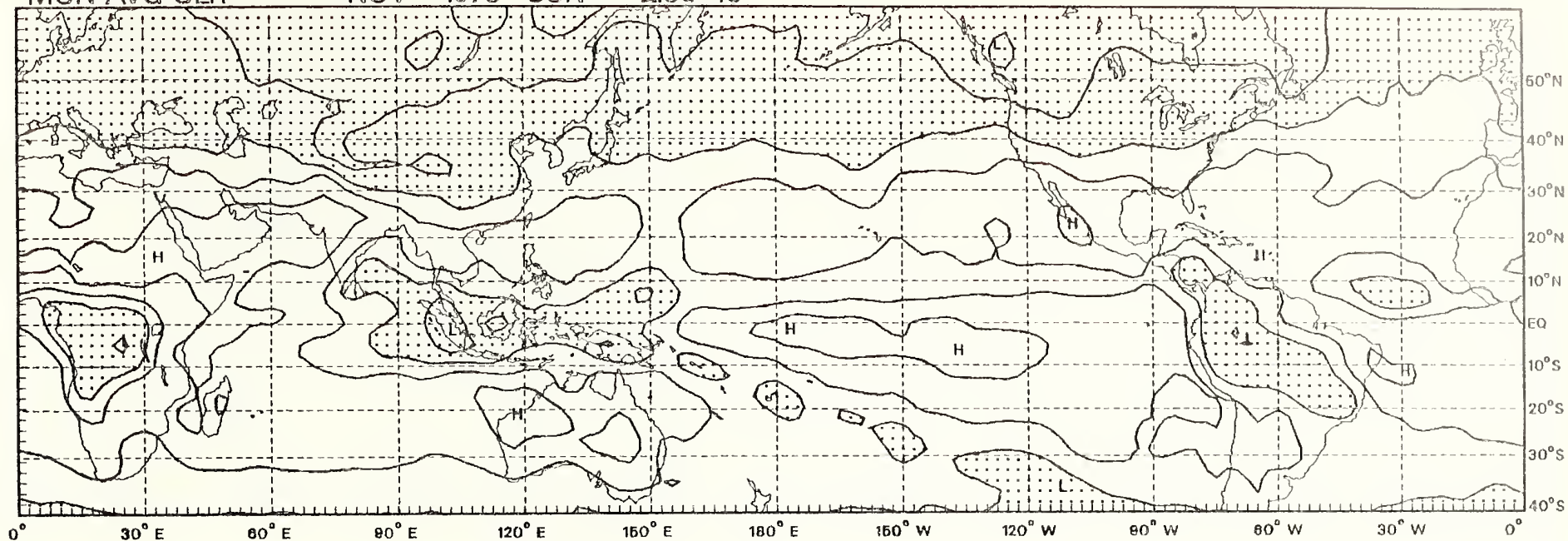




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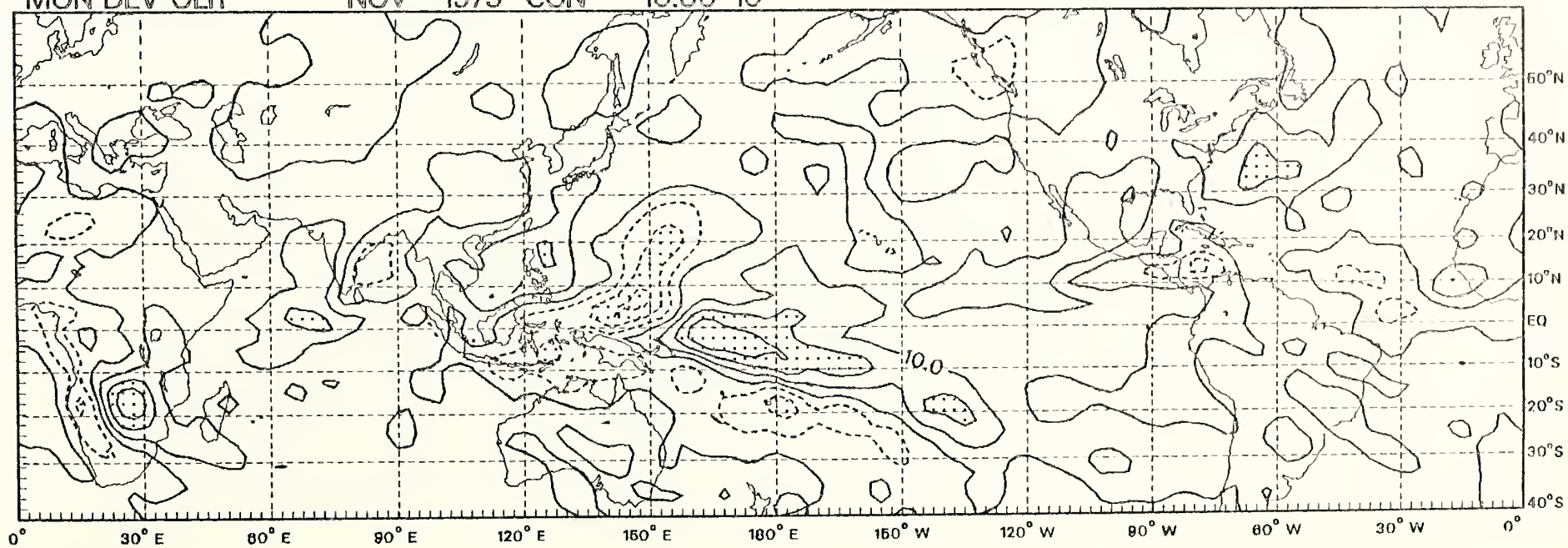
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MON DEV OLR

NOV 1975 CON =  $10.00 \times 10^0$

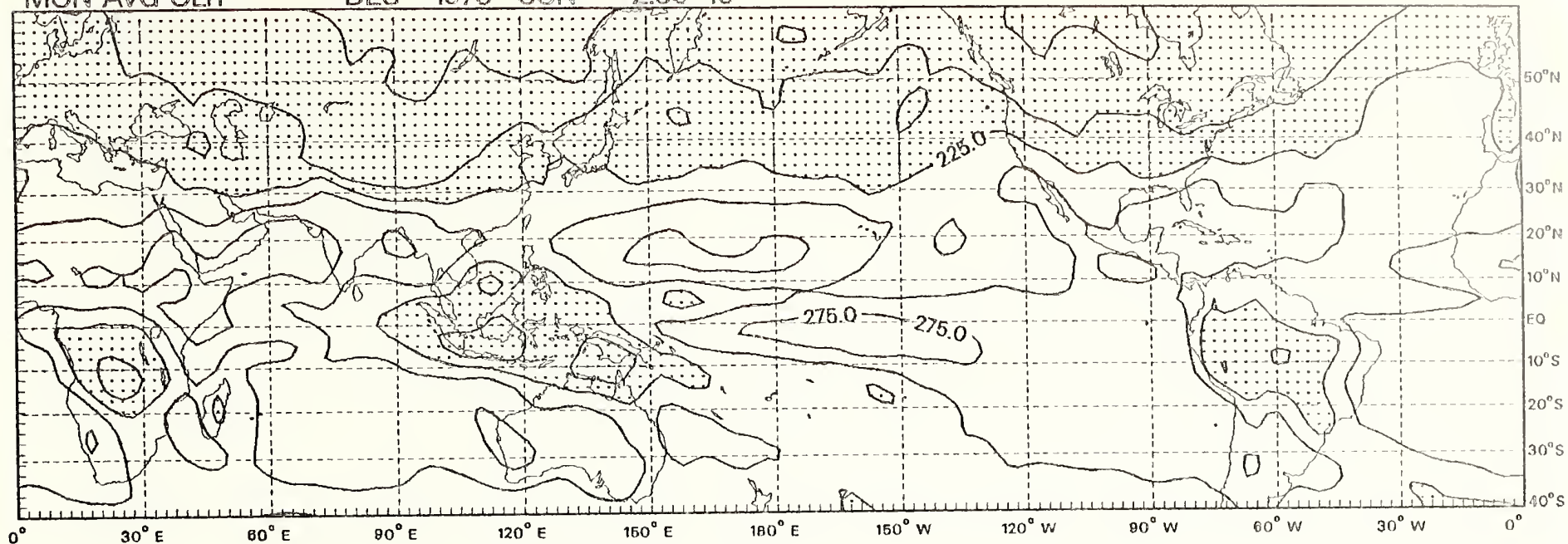
D10



MON AVG OLR

DEC 1975 CON =  $2.50 \times 10^1$

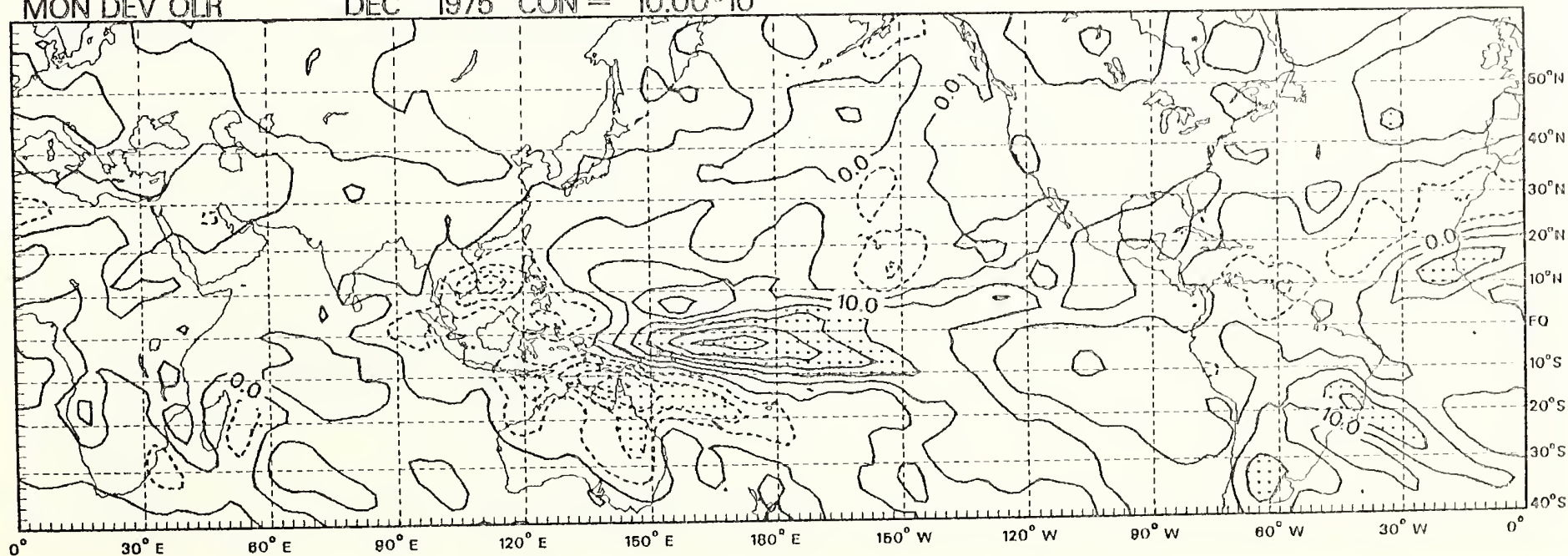
D11



MON DEV OLR

DEC 1975 CON =  $10.00 \times 10^0$

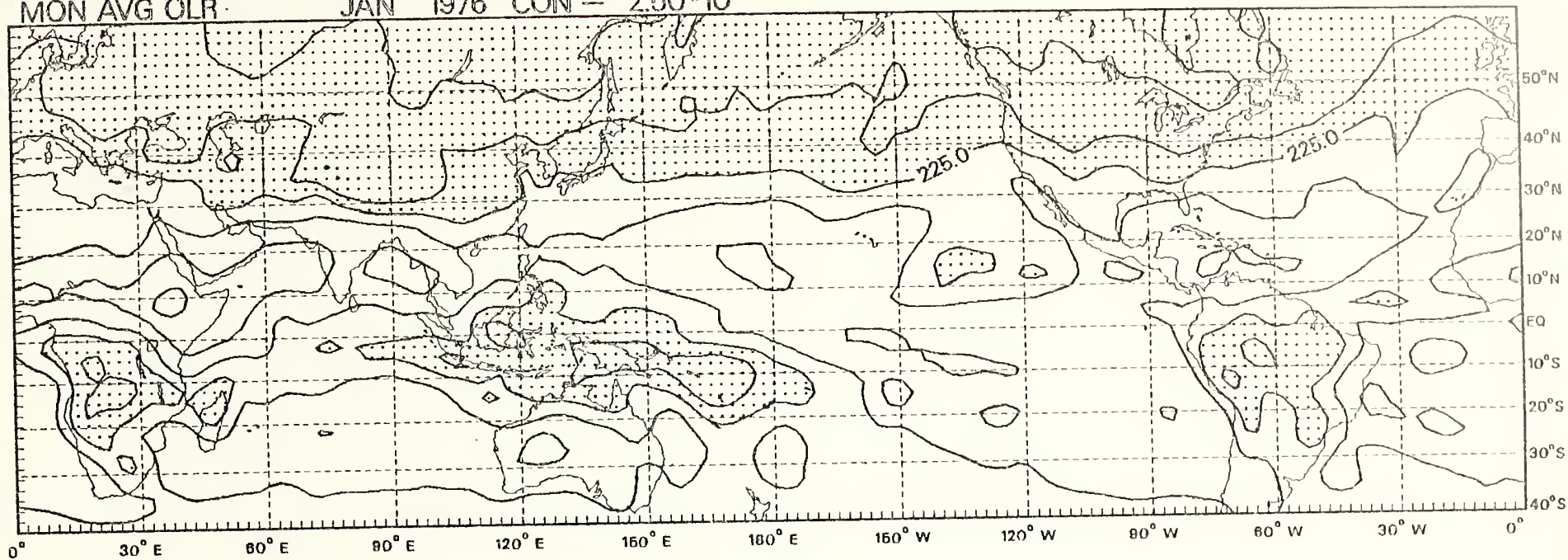
D12





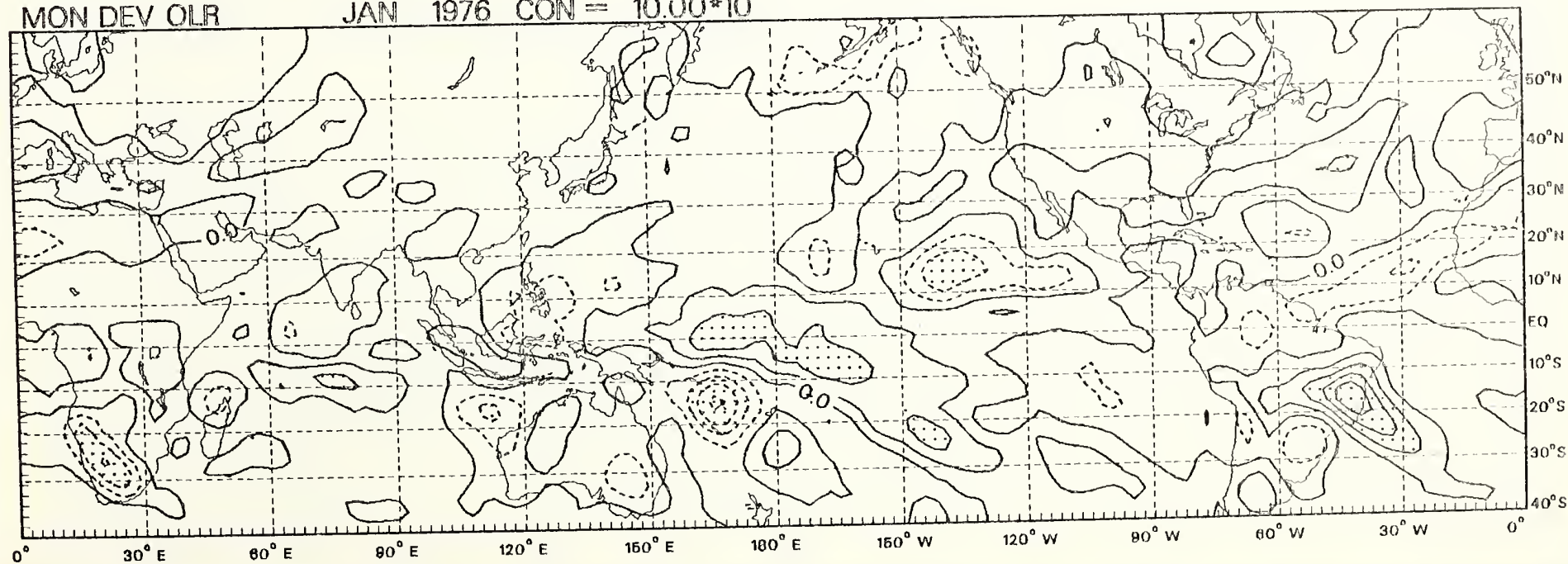
MON AVG OLR JAN 1976 CON =  $2.50 \times 10^1$

D13



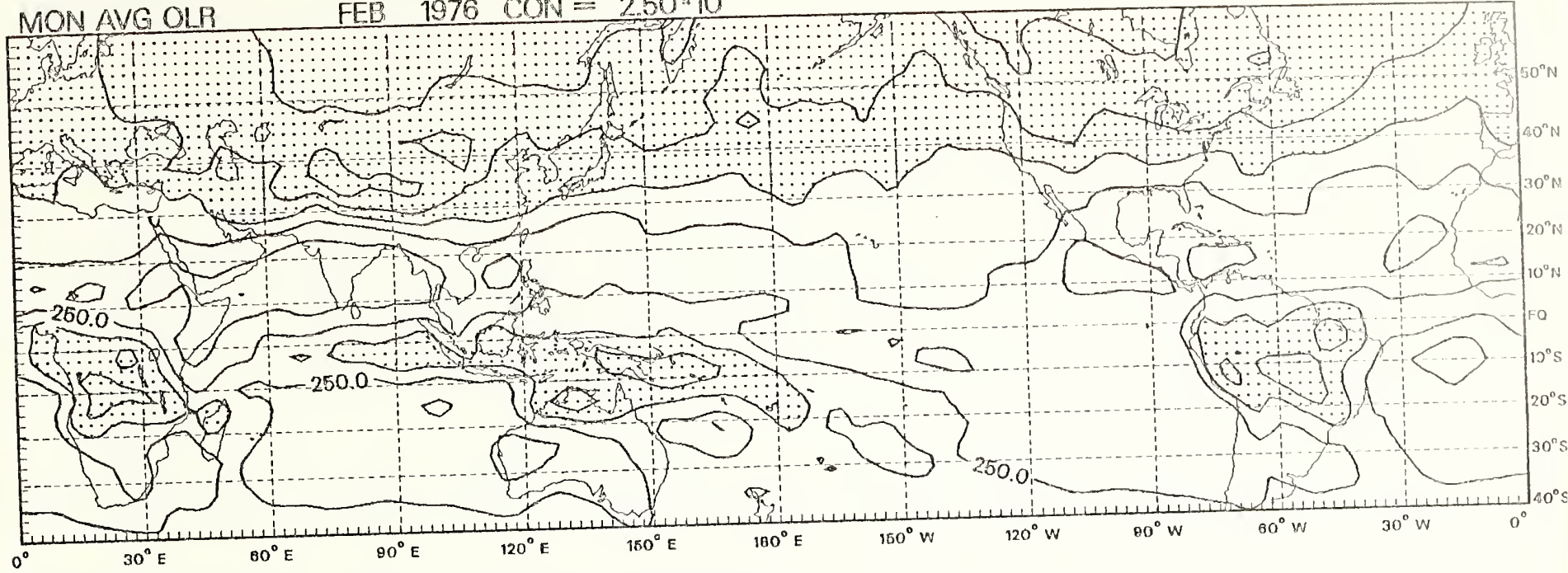
MON DEV OLR JAN 1976 CON =  $10.00 \times 10^0$

D14



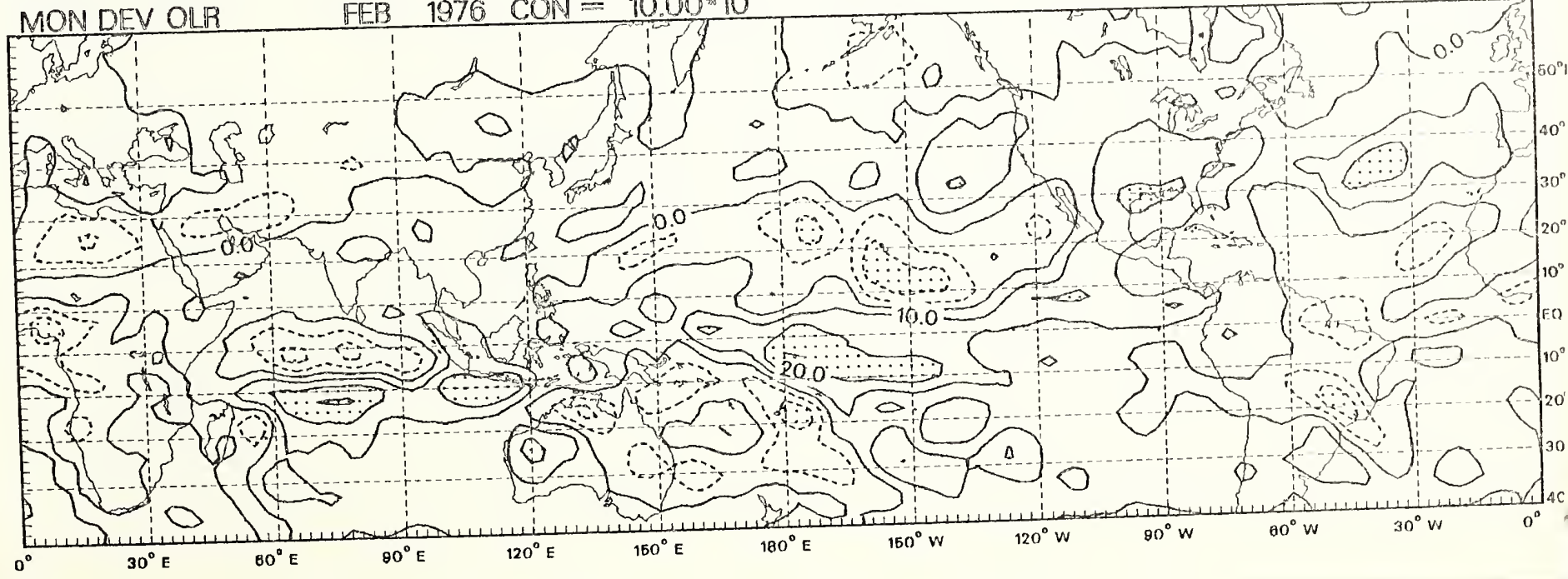
D15

MON AVG OLR FEB 1976 CON =  $2.50 \times 10^1$



D16

MON DEV OLR FEB 1976 CON =  $10.00 \times 10^0$

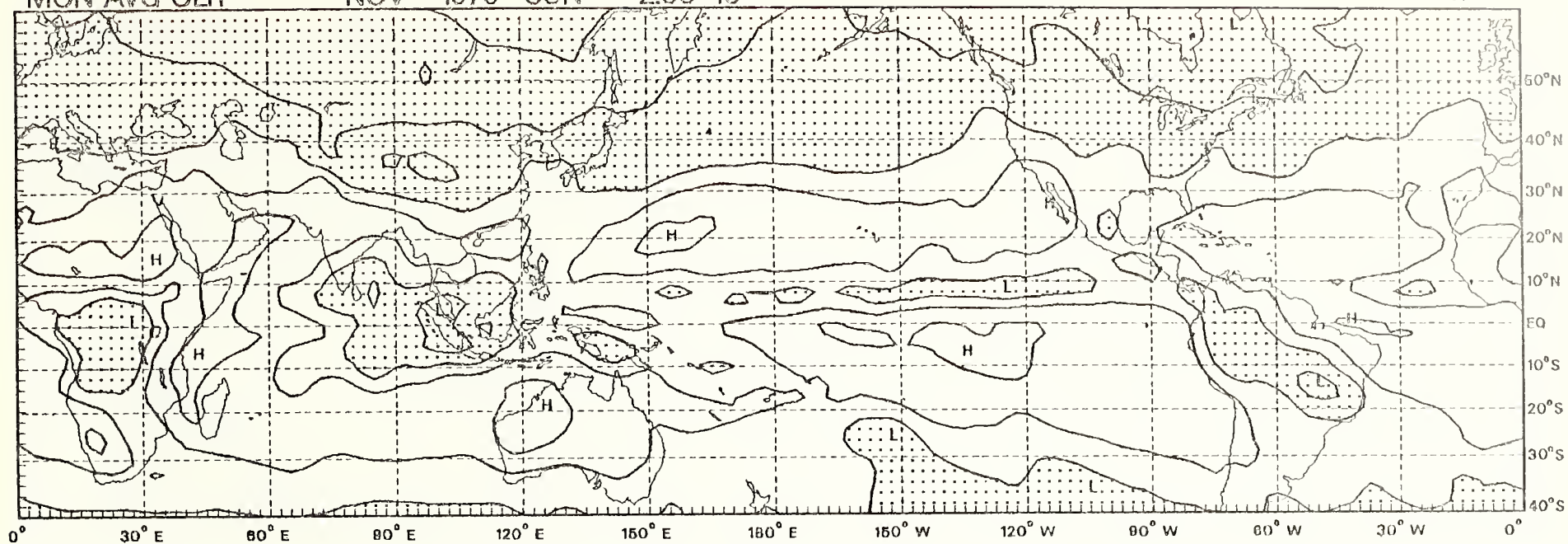




MON AVG OLR

NOV 1976 CON =  $2.50 \times 10^1$

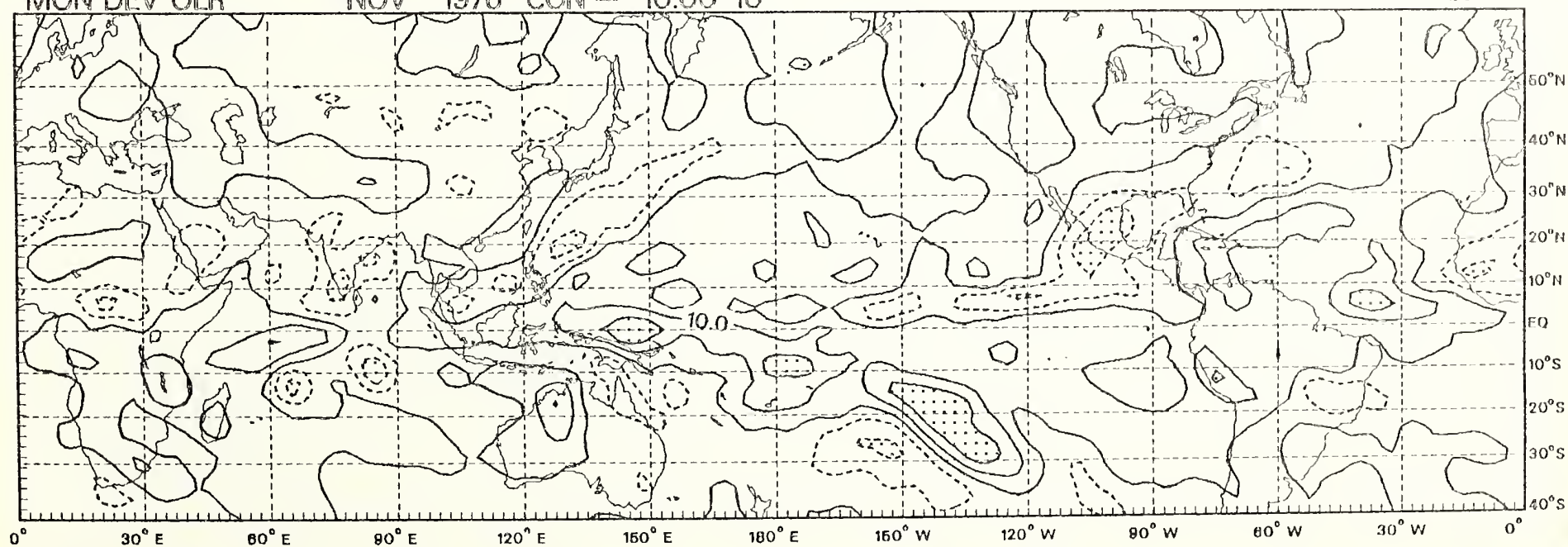
D17



MON DEV OLR

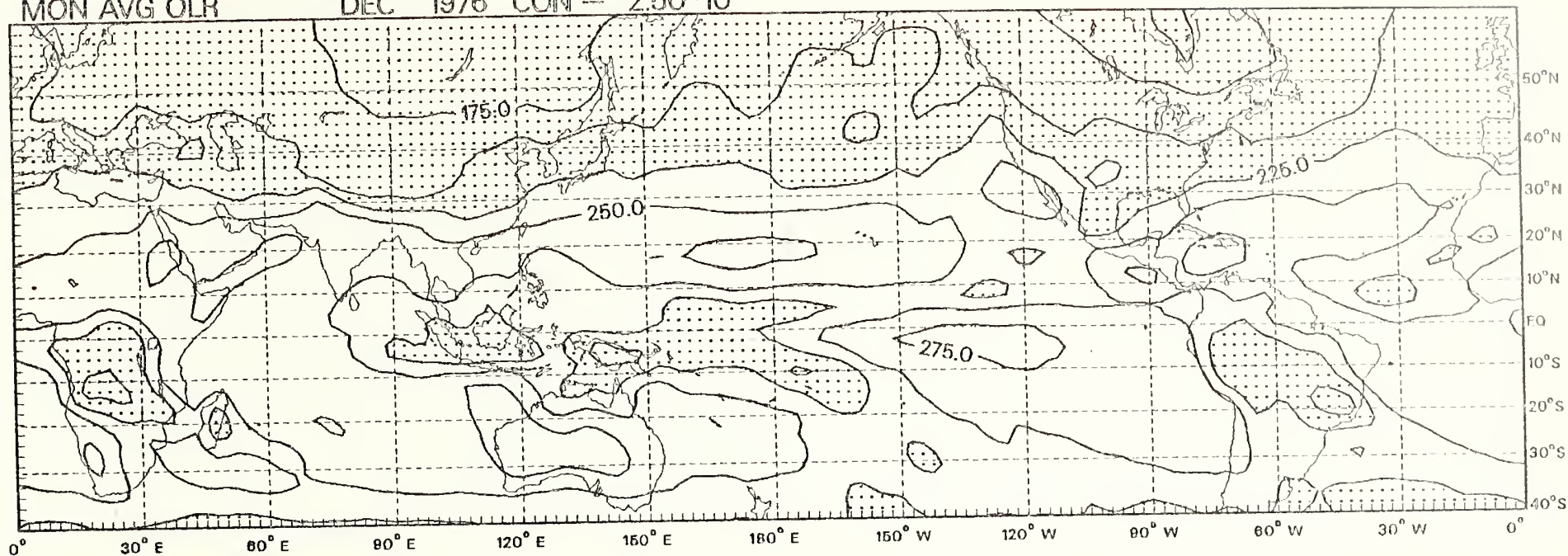
NOV 1976 CON =  $10.00 \times 10^0$

D18



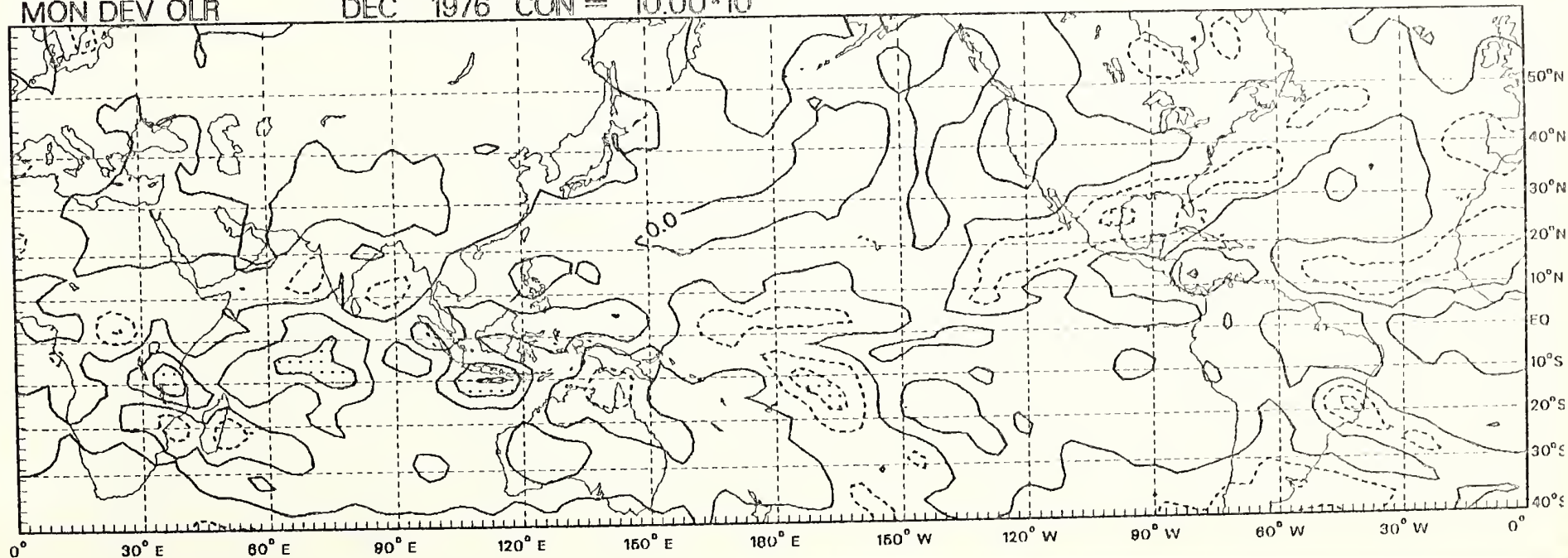
MON AVG OLR DEC 1976 CON =  $2.50 \times 10^1$

D19



MON DEV OLR DEC 1976 CON =  $10.00 \times 10^0$

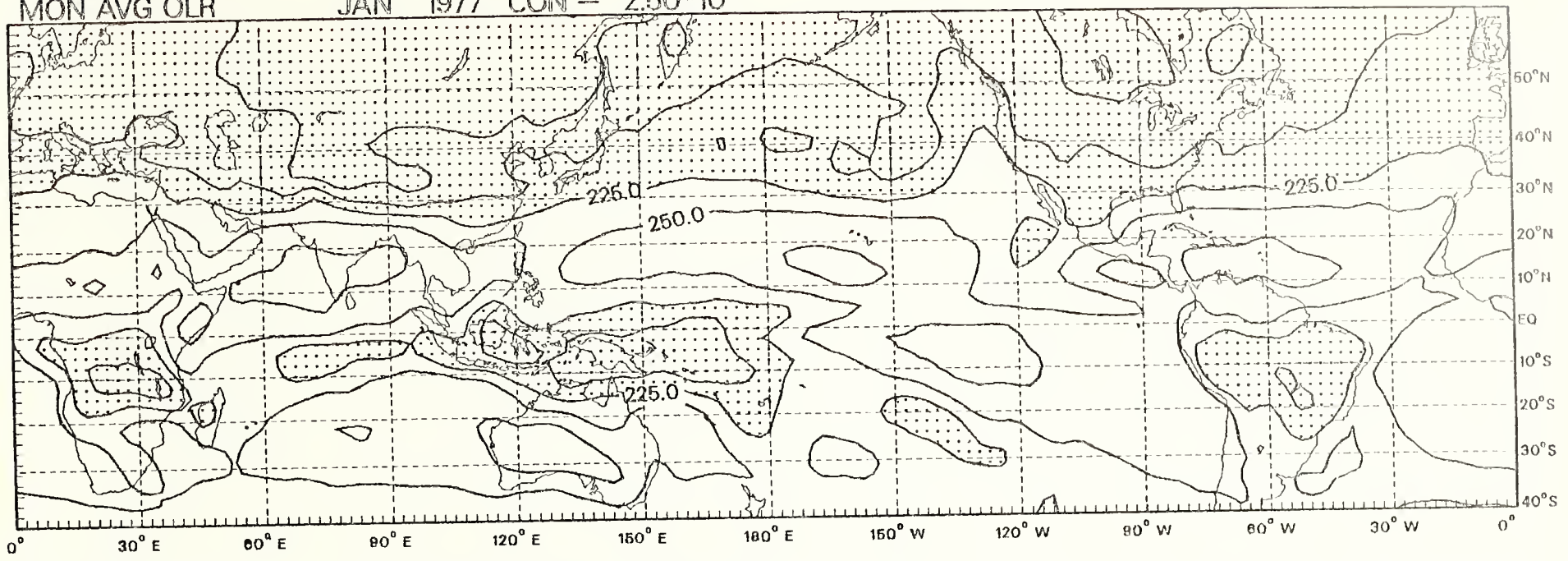
D20





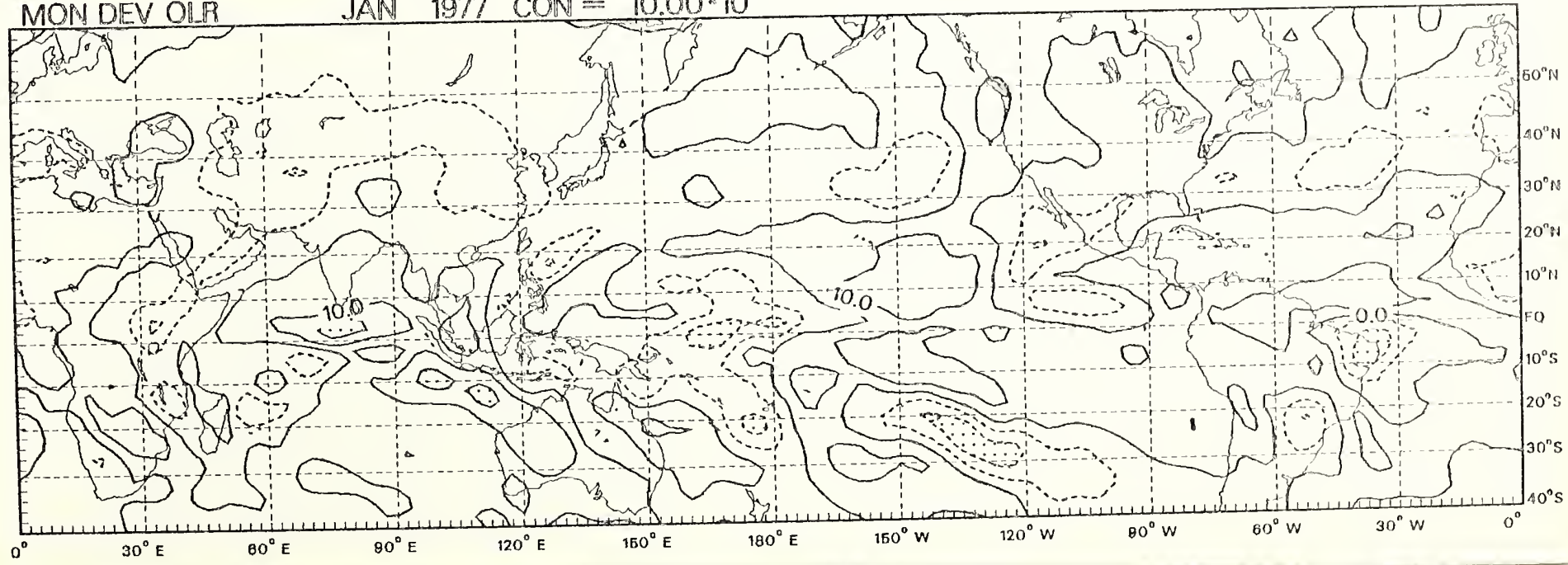
MON AVG OLR JAN 1977 CON =  $2.50 \times 10^1$

D21



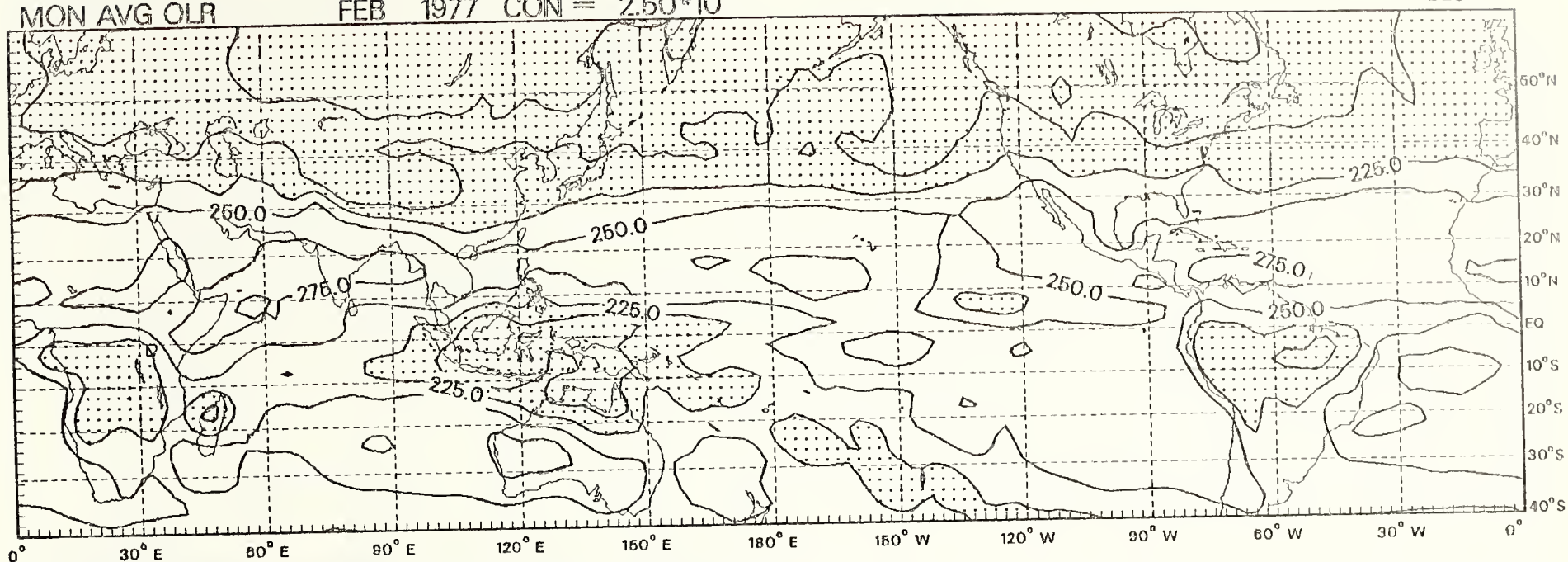
MON DEV OLR JAN 1977 CON =  $10.00 \times 10^0$

D22



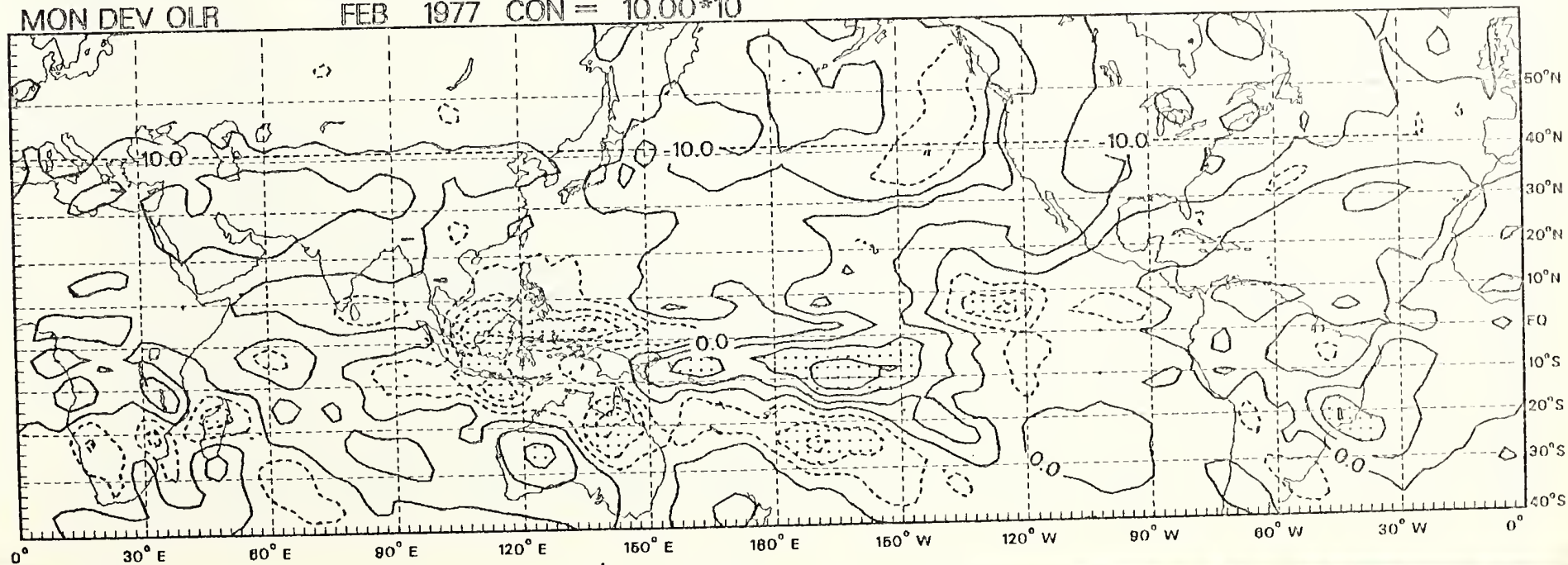
MON AVG OLR FEB 1977 CON =  $2.50 \times 10^1$

D23



MON DEV OLR FEB 1977 CON =  $10.00 \times 10^0$

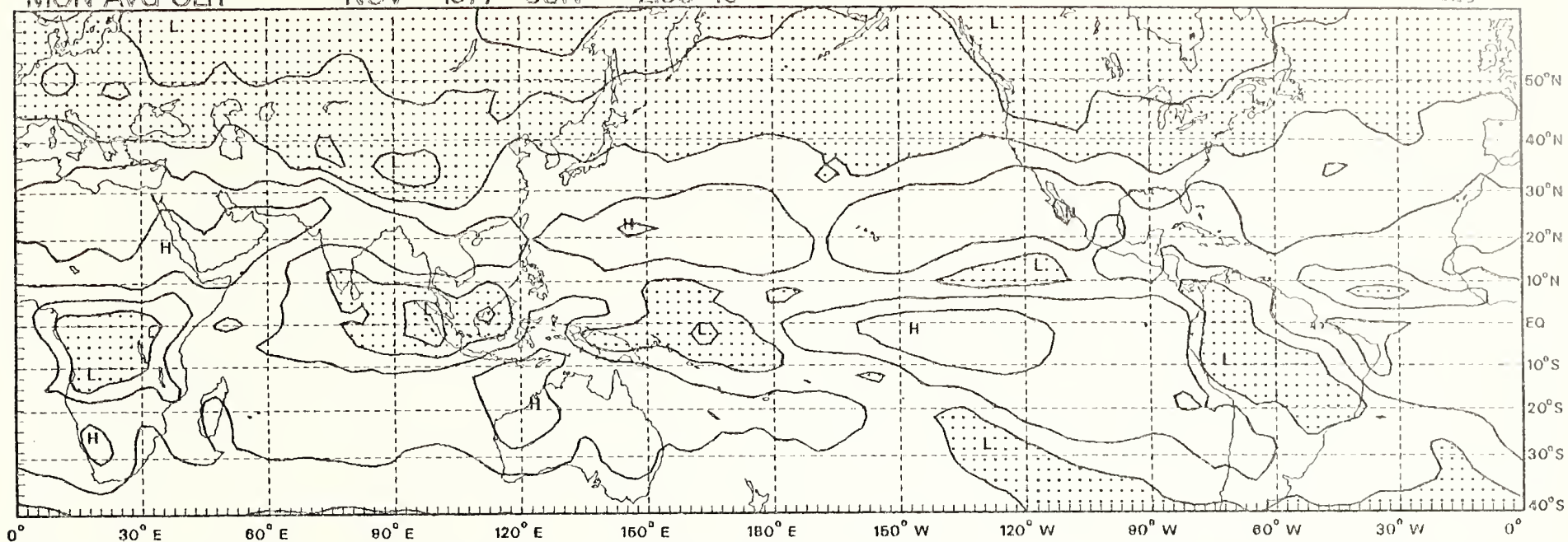
D24





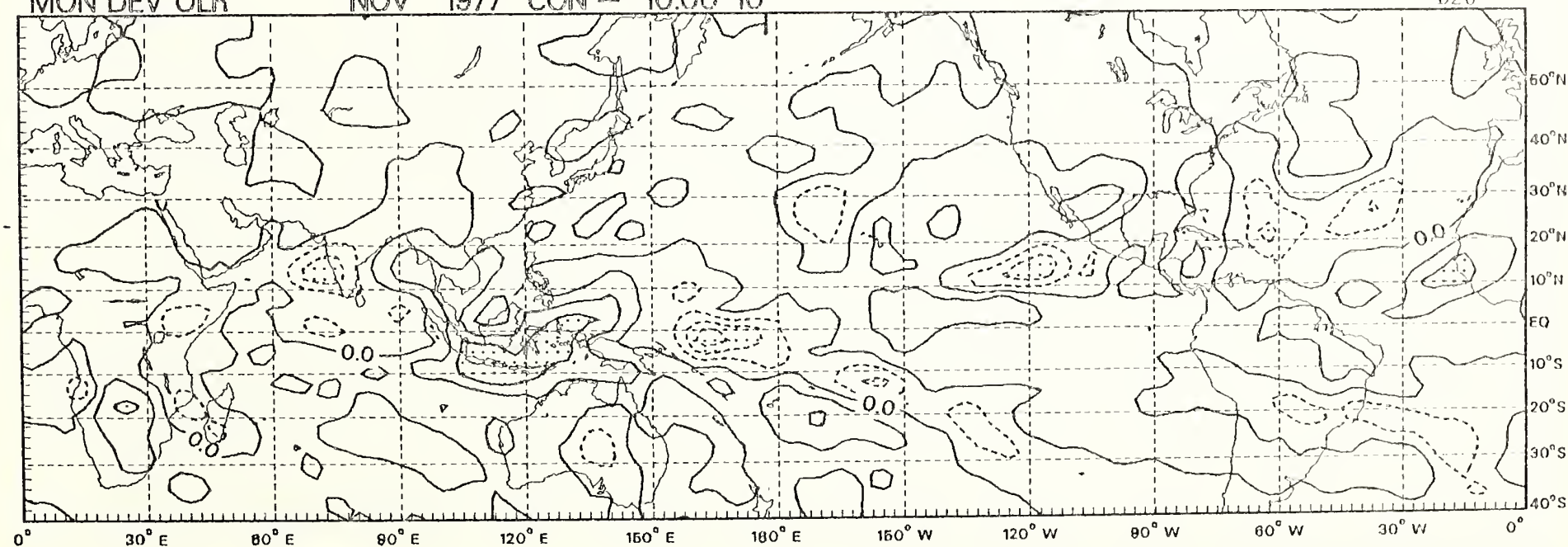
MON AVG OLR NOV 1977 CON =  $2.50 \times 10^1$

D25



MON DEV OLR NOV 1977 CON =  $10.00 \times 10^0$

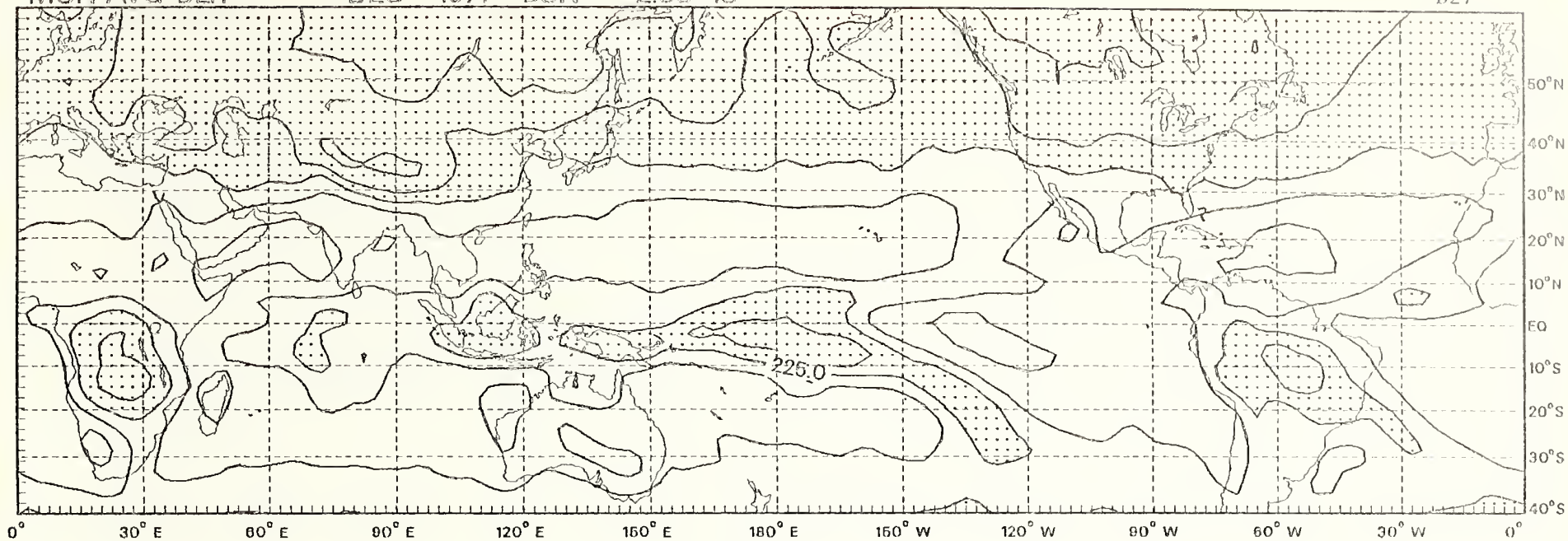
D26



MON AVG OLR

DEC 1977 CON =  $2.50 \times 10^1$

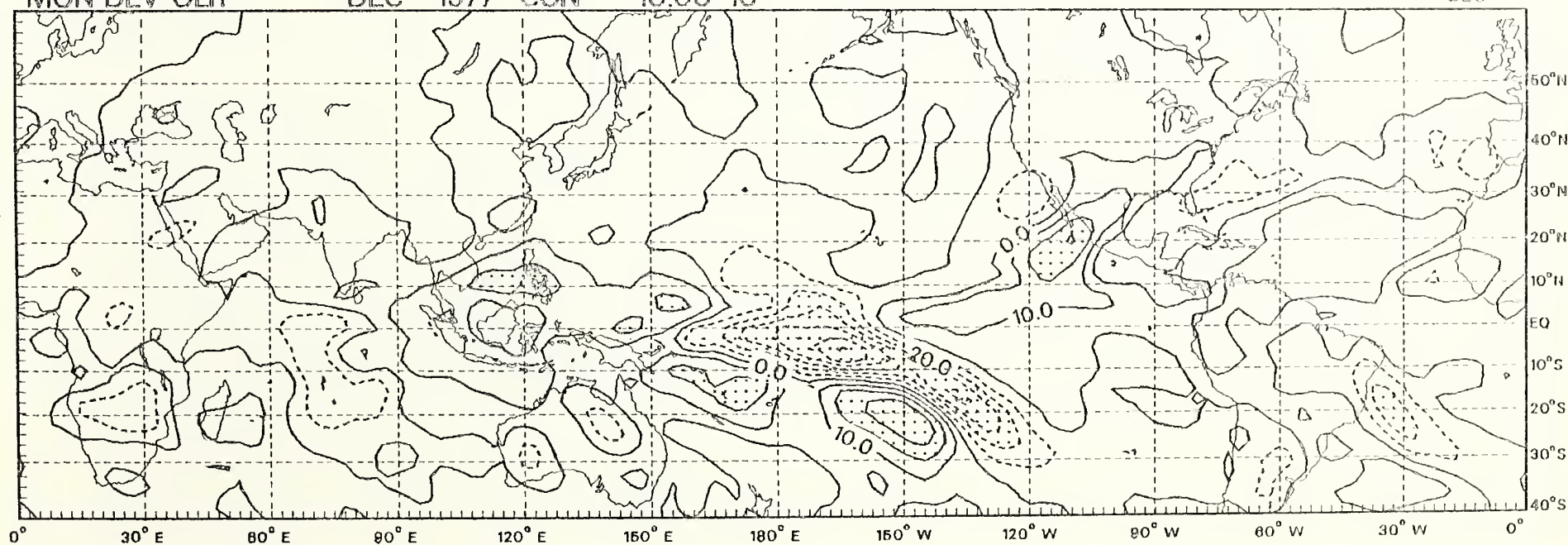
D27



MON DEV OLR

DEC 1977 CON =  $10.00 \times 10^0$

D28

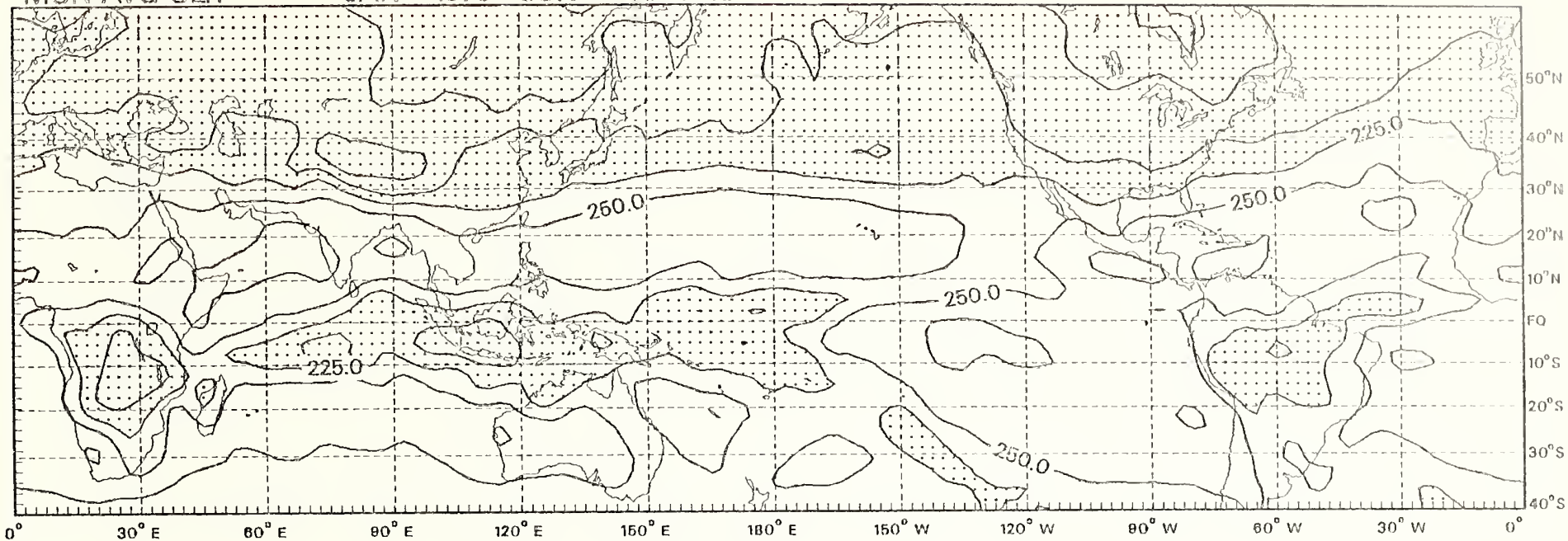




MON AVG OLR

JAN 1978 CON =  $2.50 \times 10^1$

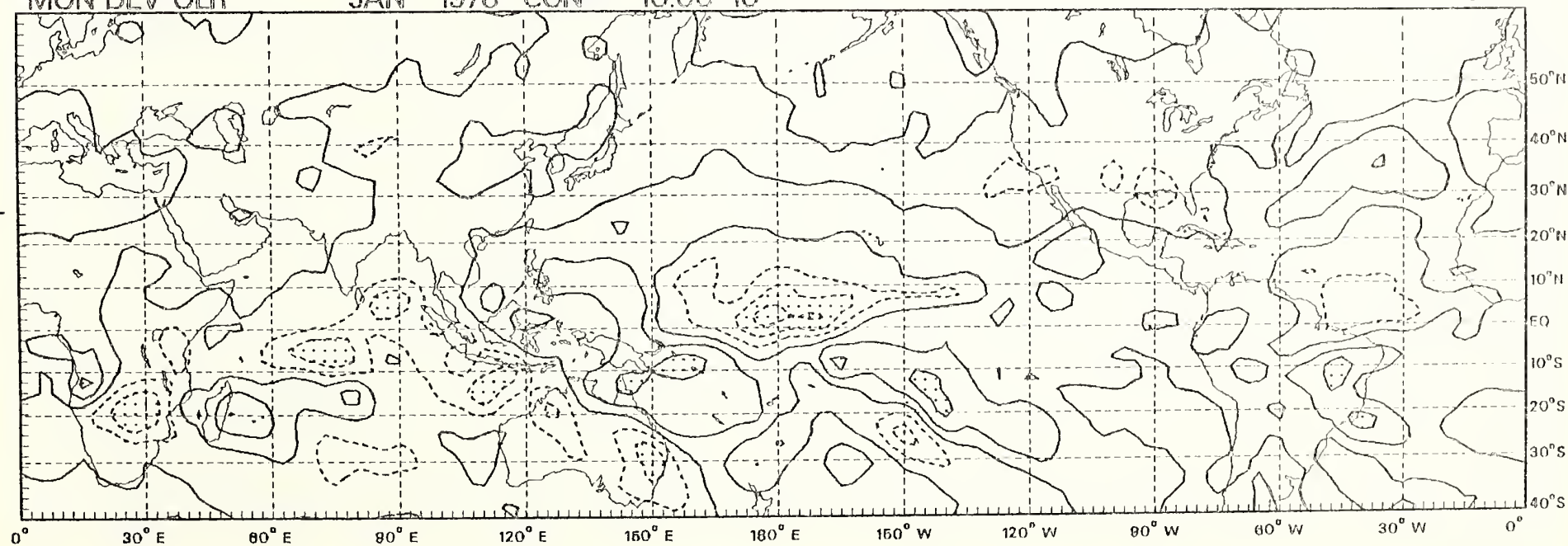
D29



MON DEV OLR

JAN 1978 CON =  $10.00 \times 10^0$

D30

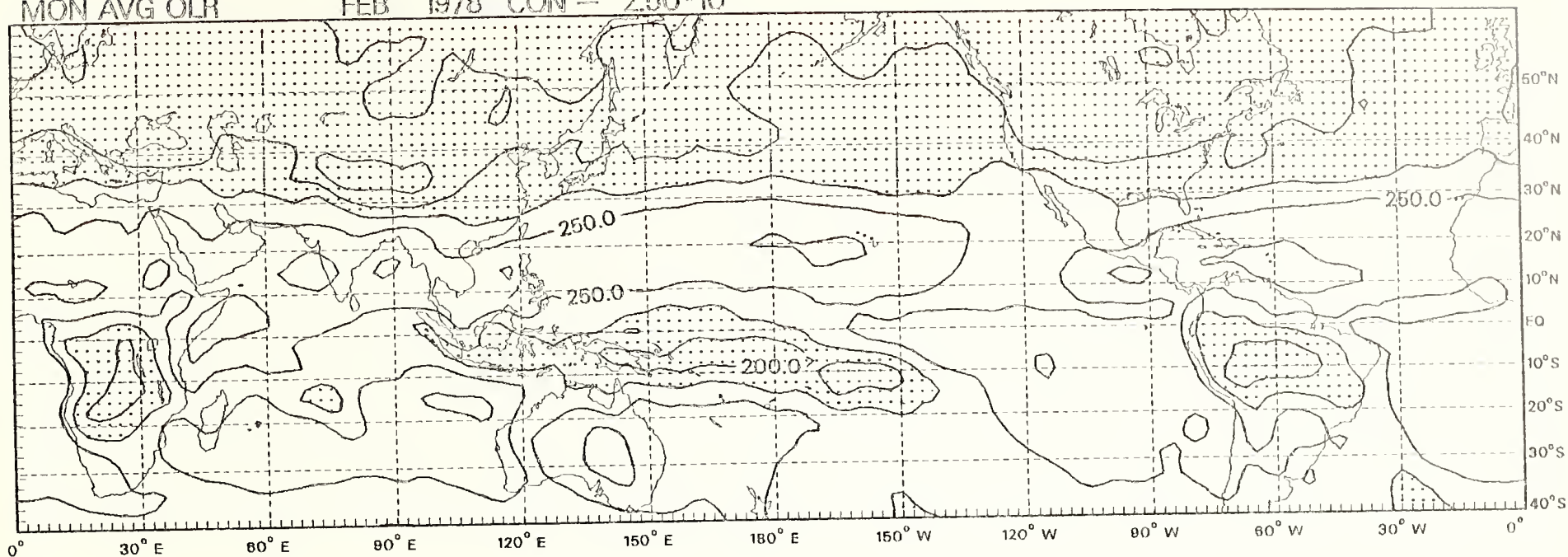




MON AVG OLR

FEB 1978 CON =  $2.50 \times 10^1$

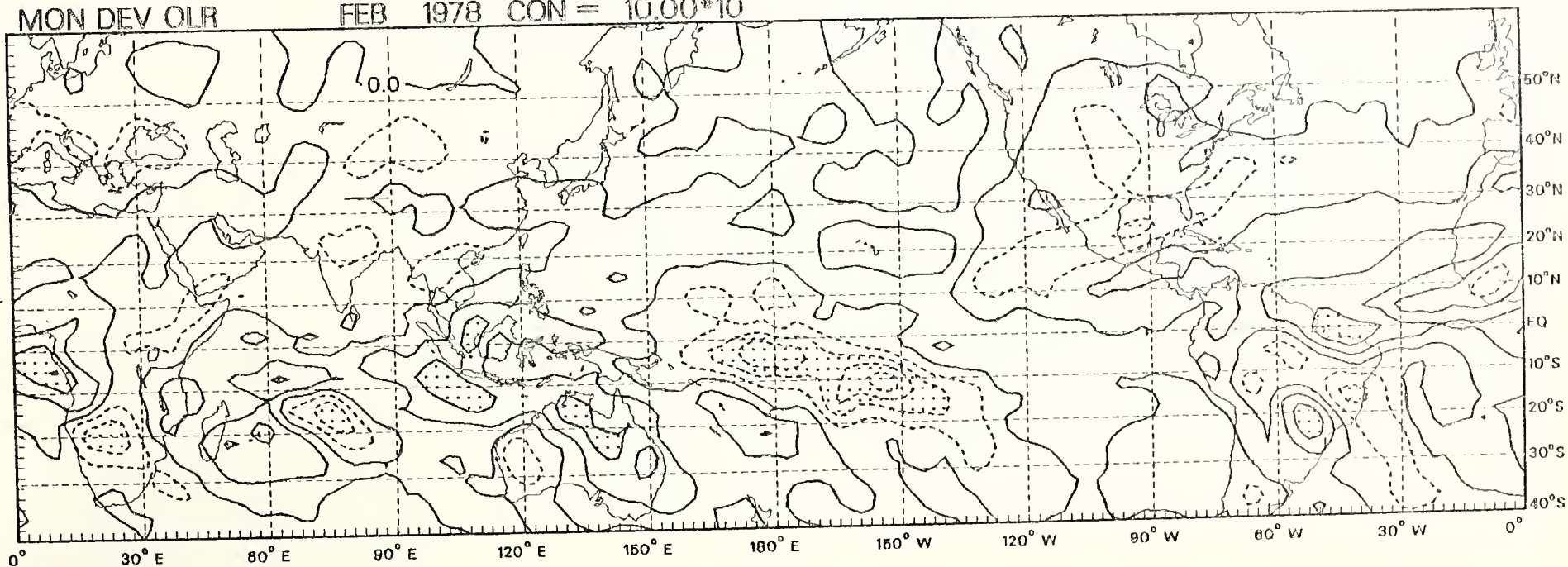
D31



MON DEV OLR

FEB 1978 CON =  $10.00 \times 10^0$

D32

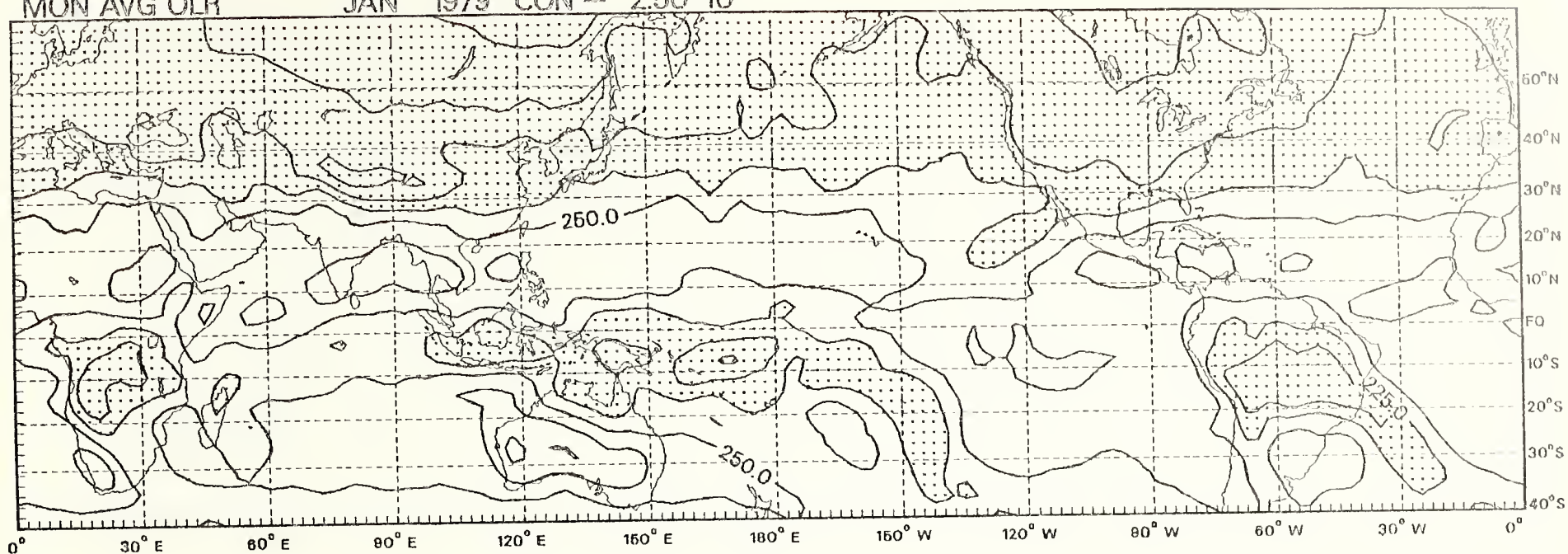


Nov 78 and Dec 78

NOT AVAILABLE

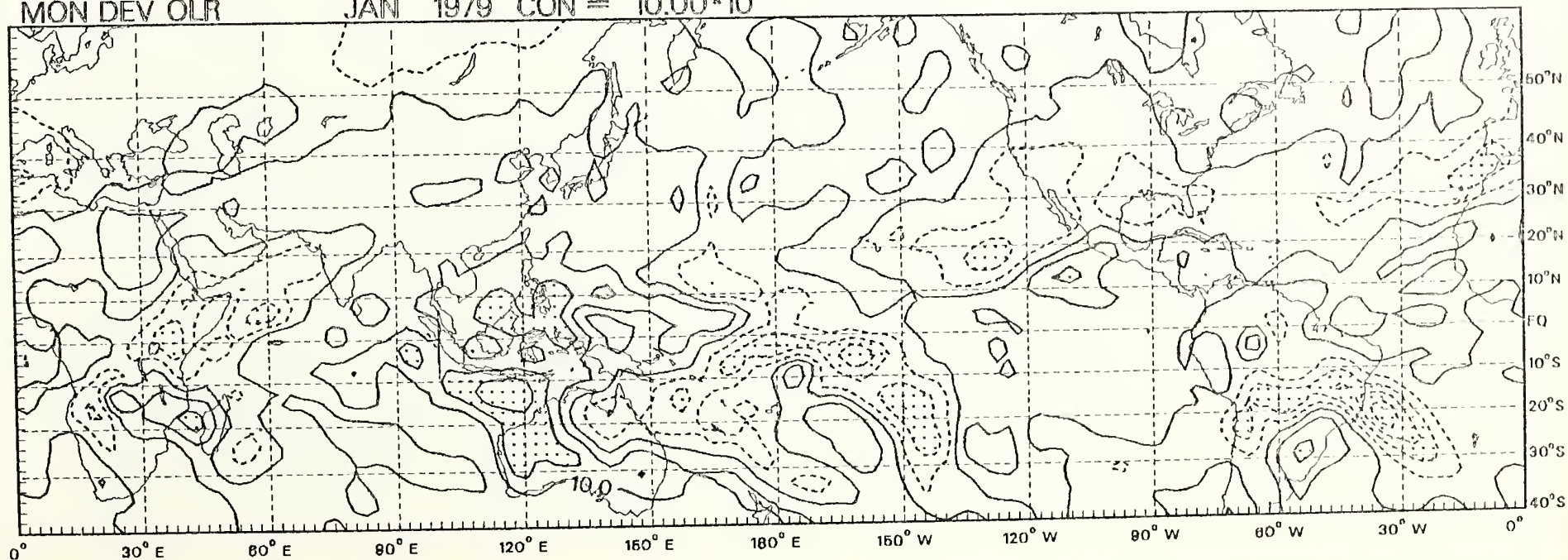
MON AVG OLR JAN 1979 CON =  $2.50 \times 10^1$

D33



MON DEV OLR JAN 1979 CON =  $10.00 \times 10^0$

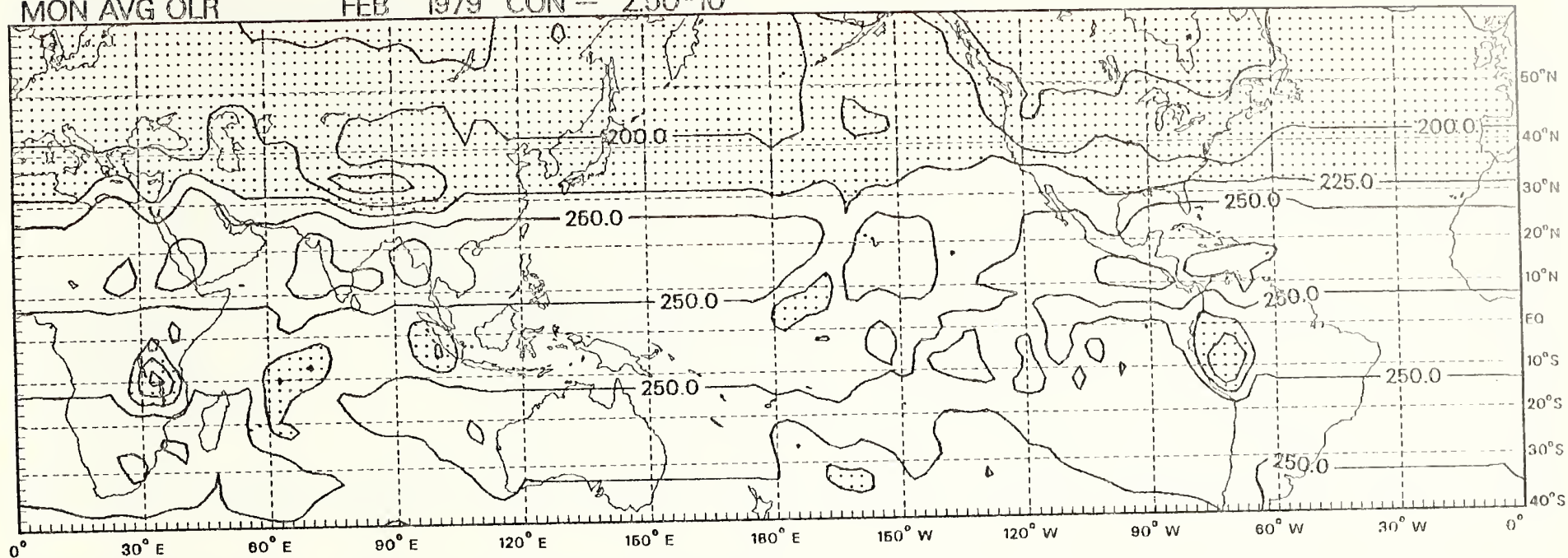
D34





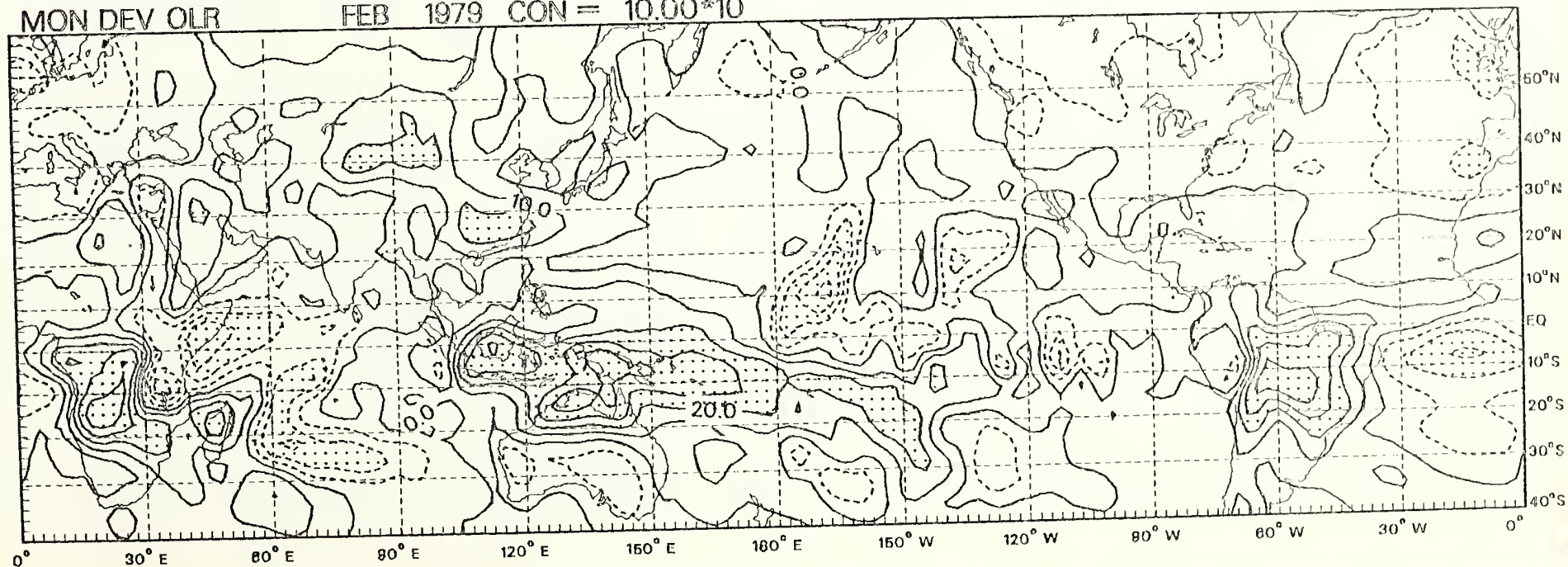
MON AVG OLR FEB 1979 CON =  $2.50 \times 10^1$

D35



MON DEV OLR FEB 1979 CON =  $10.00 \times 10^0$

D36

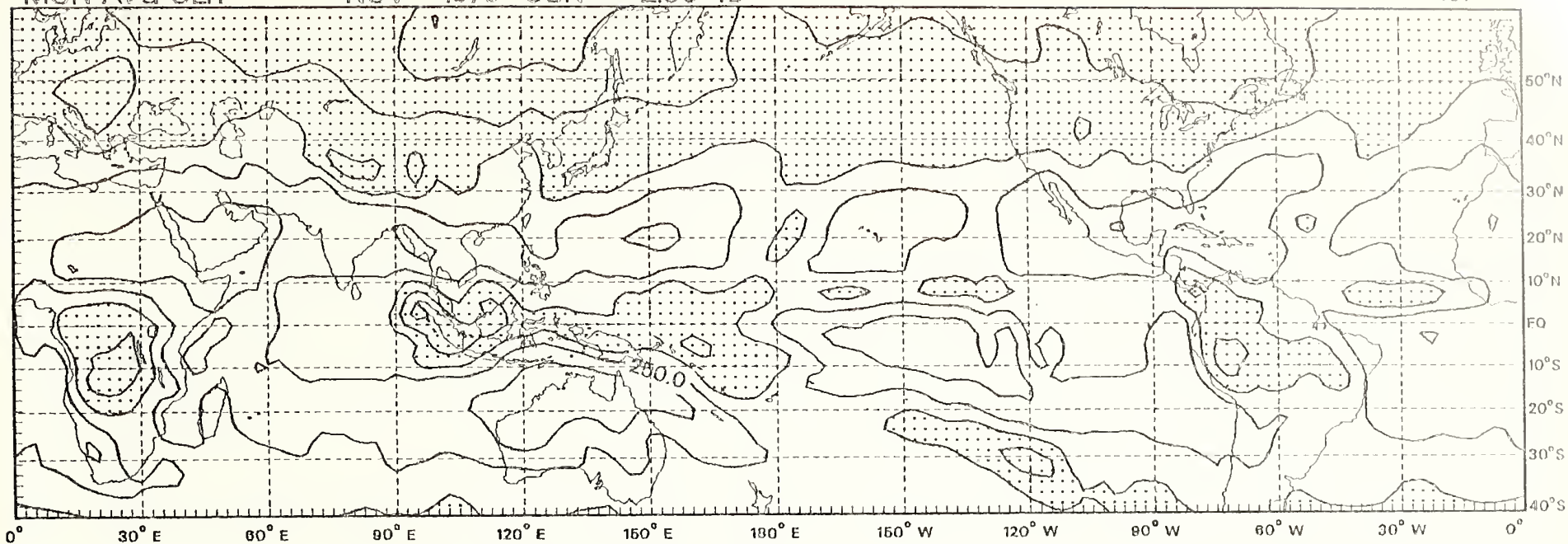




MON AVG OLR

NOV 1979 CON =  $2.50 \times 10^1$

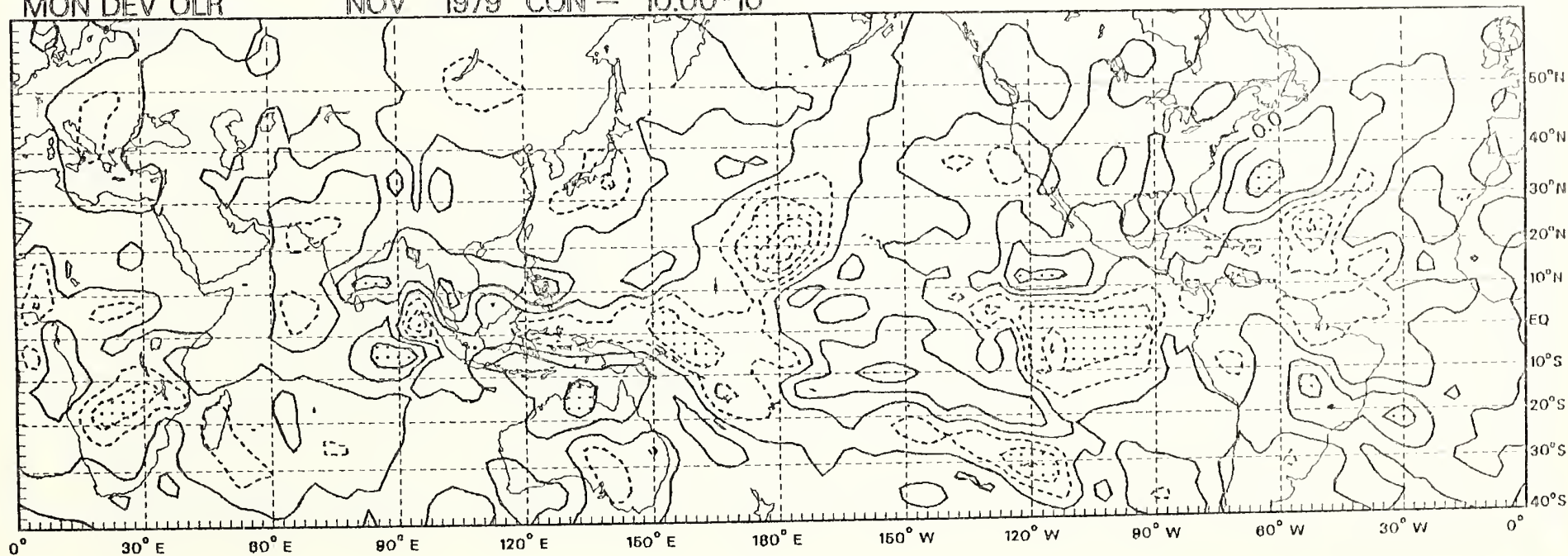
D37



MON DEV OLR

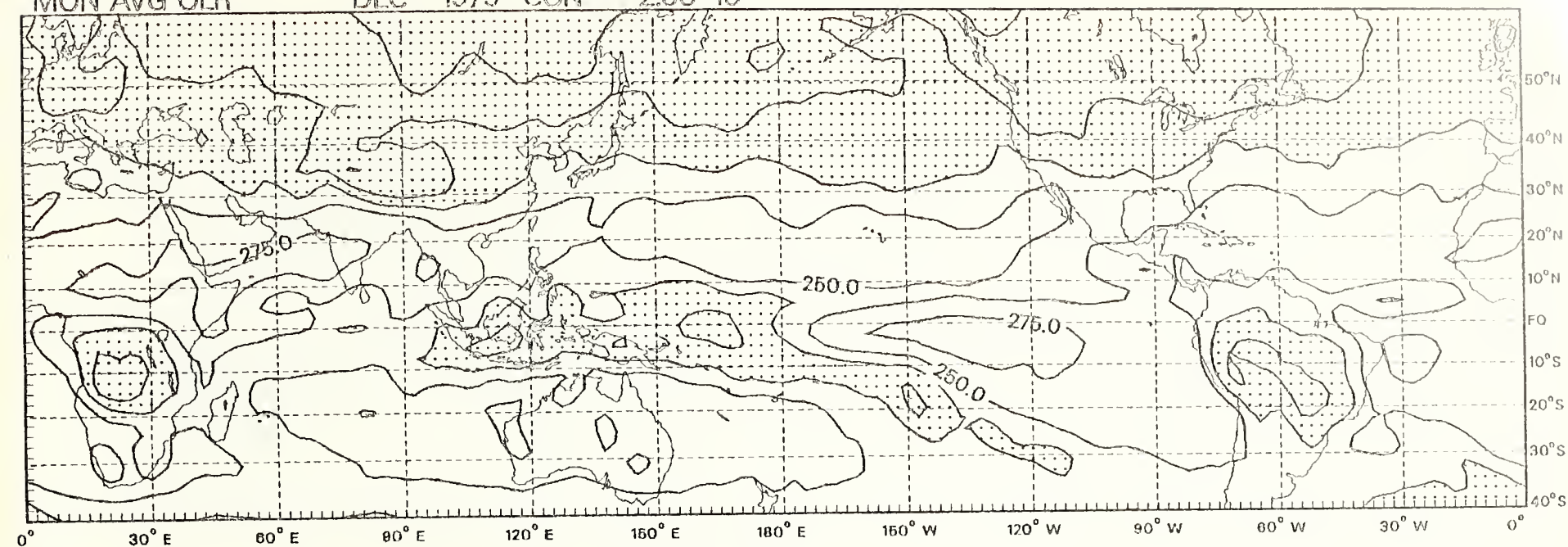
NOV 1979 CON =  $10.00 \times 10^0$

D38



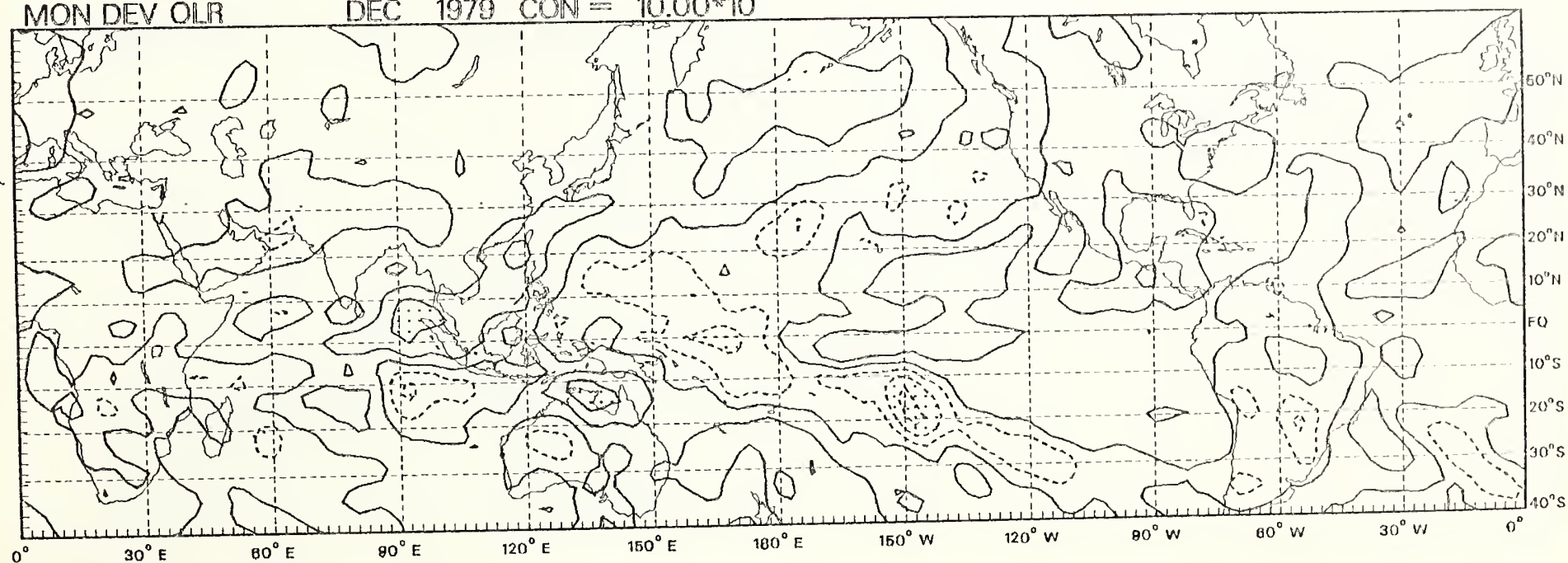
MON AVG OLR DEC 1979 CON =  $2.50 \times 10^1$

D39



MON DEV OLR DEC 1979 CON =  $10.00 \times 10^0$

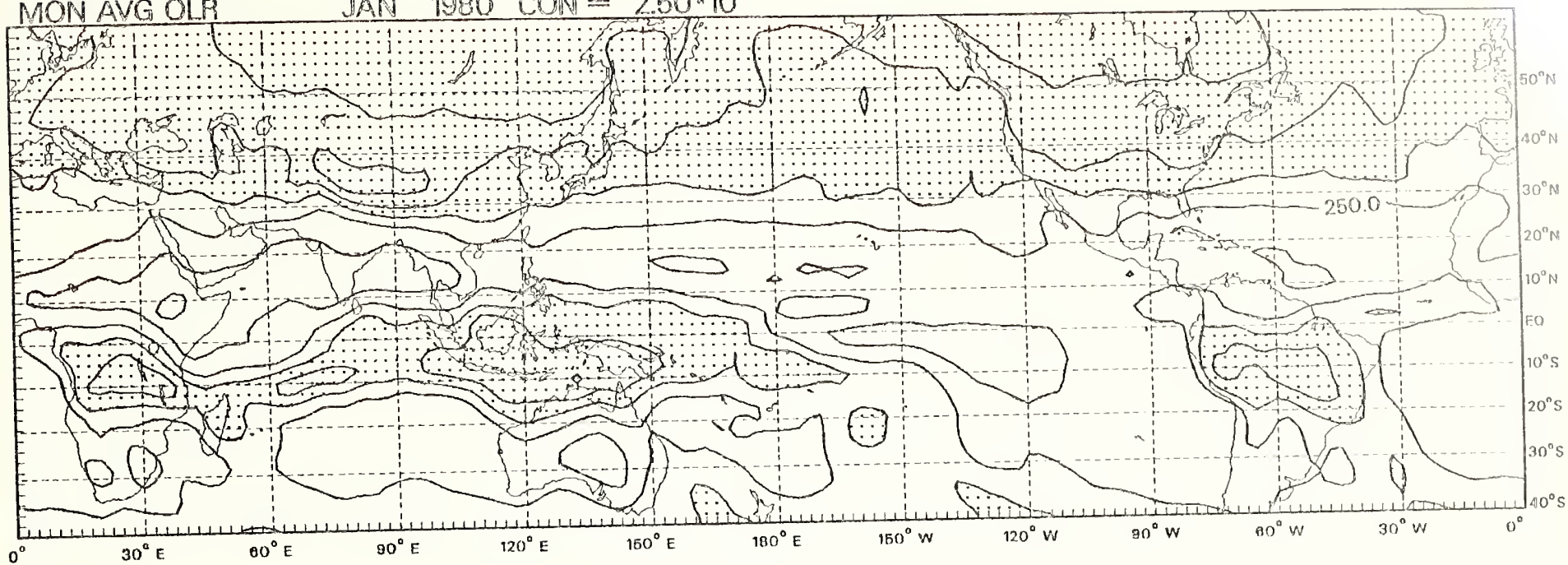
D40





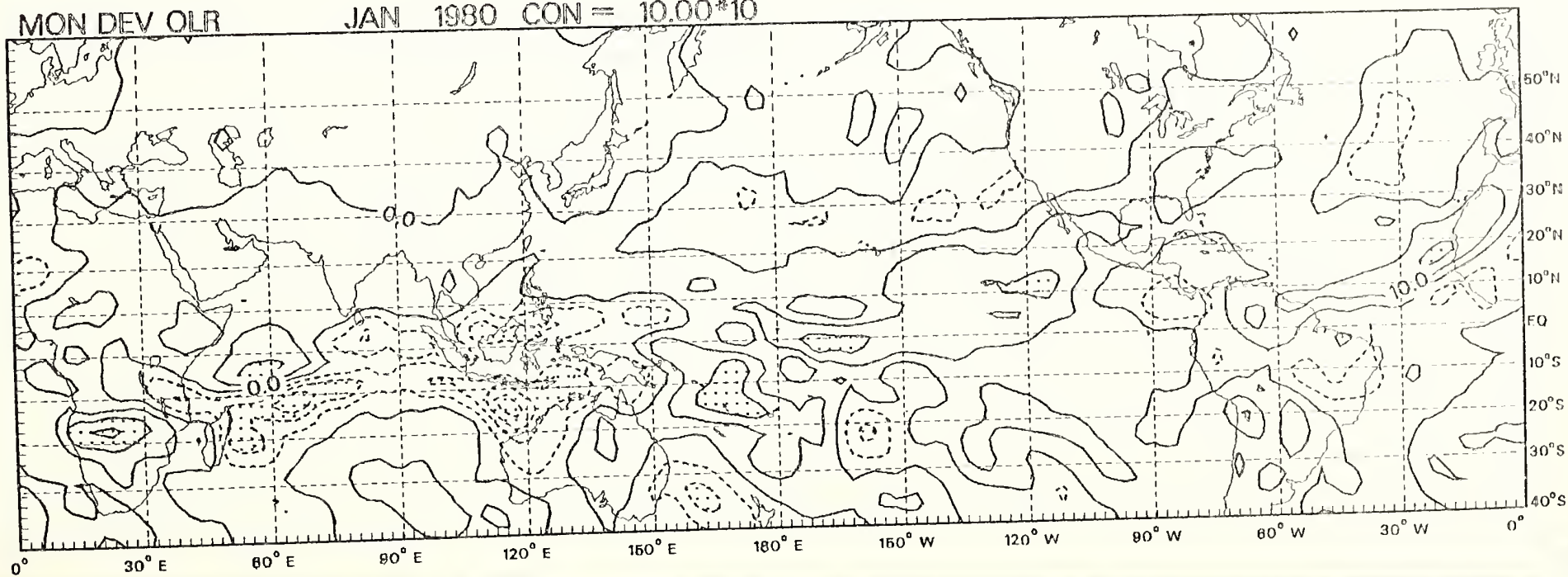
MON AVG OLR JAN 1980 CON =  $2.50 \times 10^1$

D41



MON DEV OLR JAN 1980 CON =  $10.00 \times 10^0$

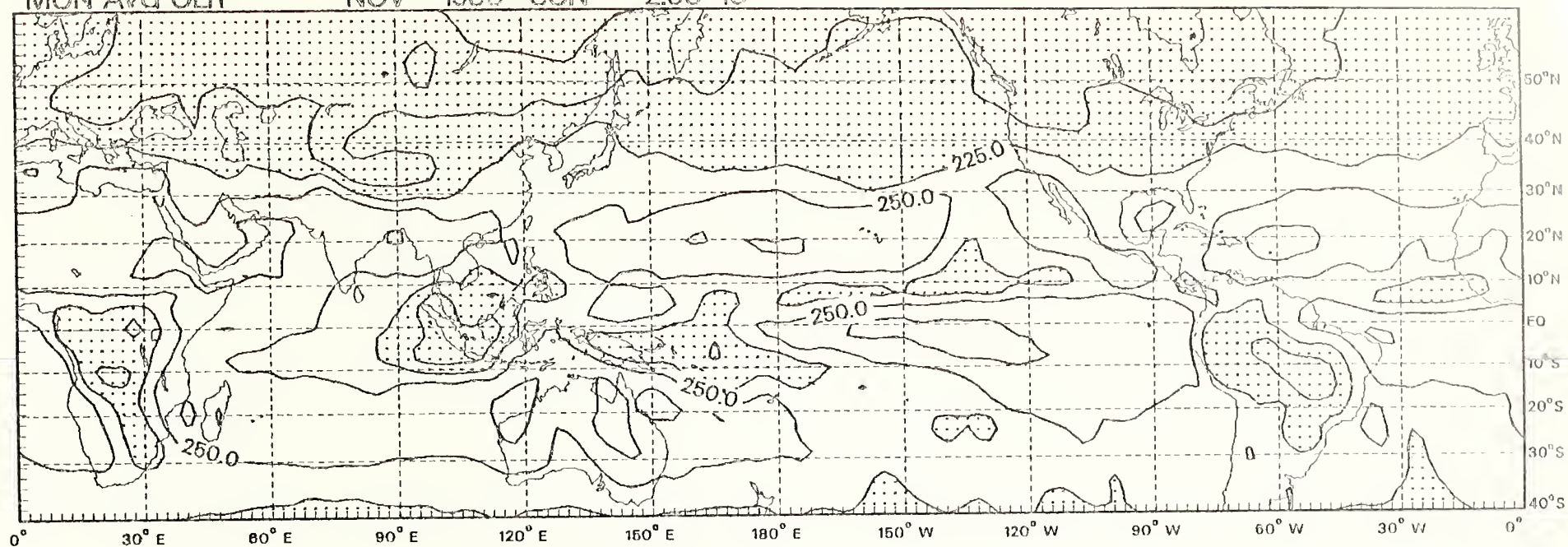
D42



MON AVG OLR

NOV 1980 CON =  $2.50 \times 10^1$

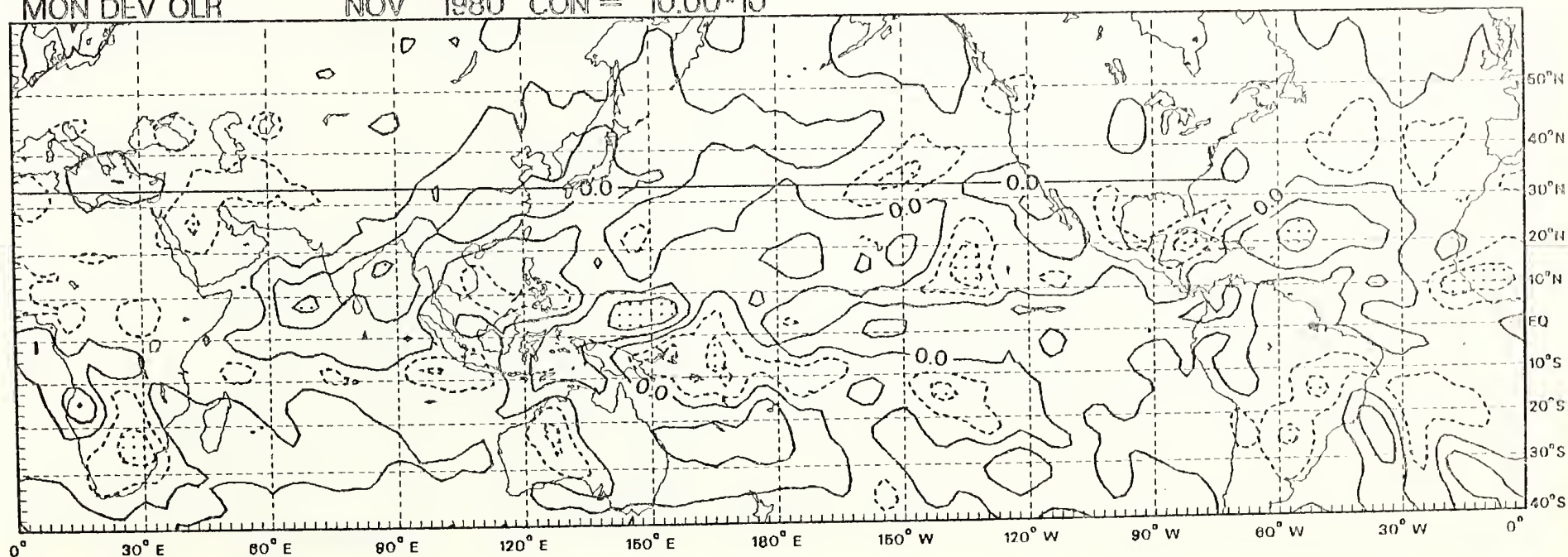
D45



MON DEV OLR

NOV 1980 CON =  $10.00 \times 10^0$

D46

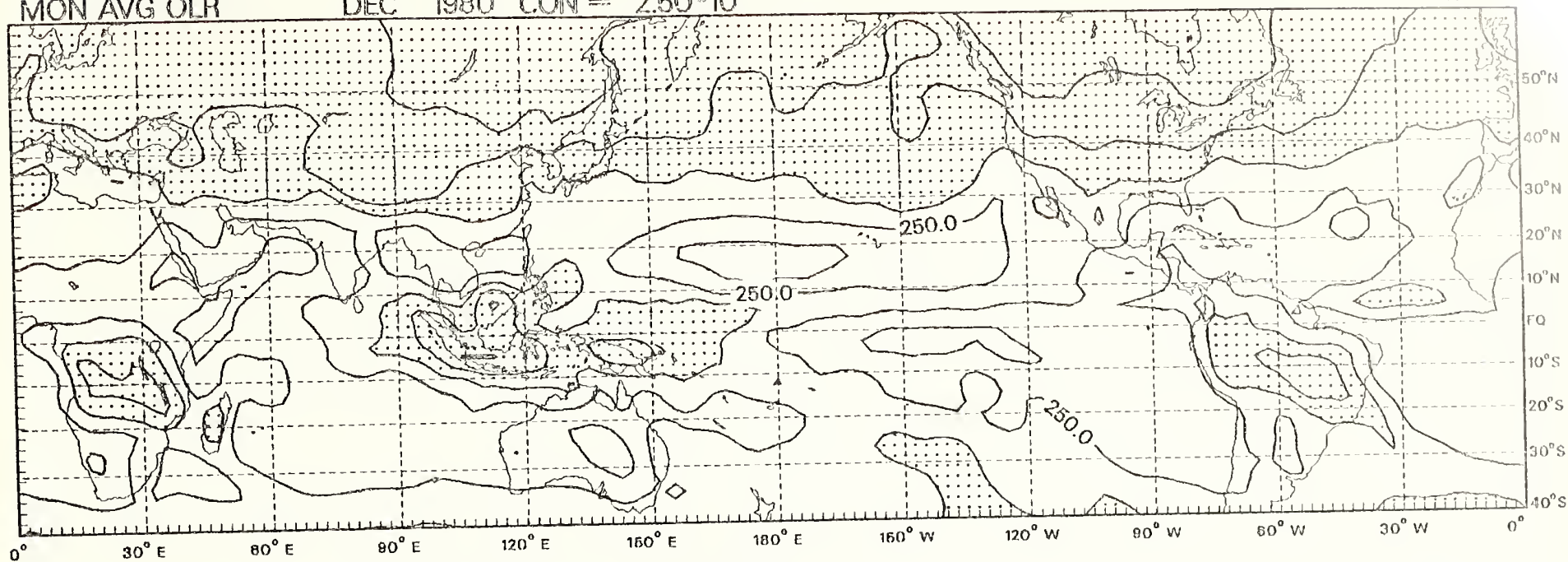




MON AVG OLR

DEC 1980 CON =  $2.50 \times 10^1$

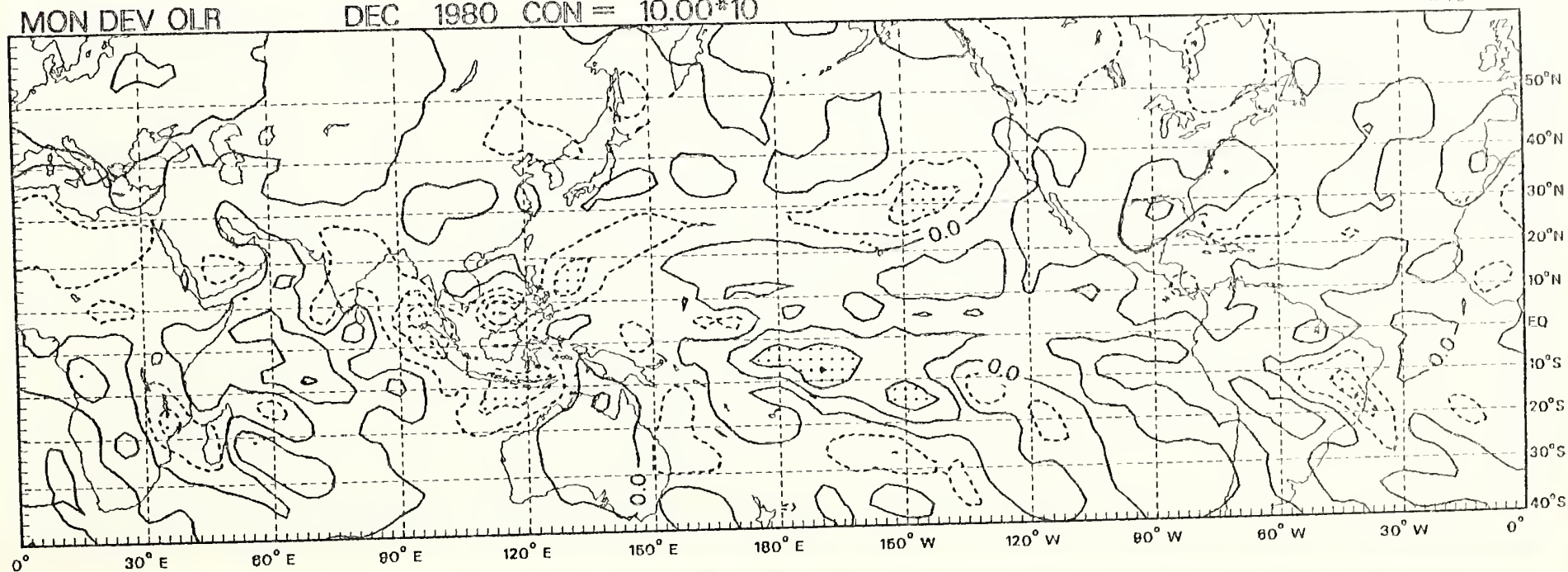
D47



MON DEV OLR

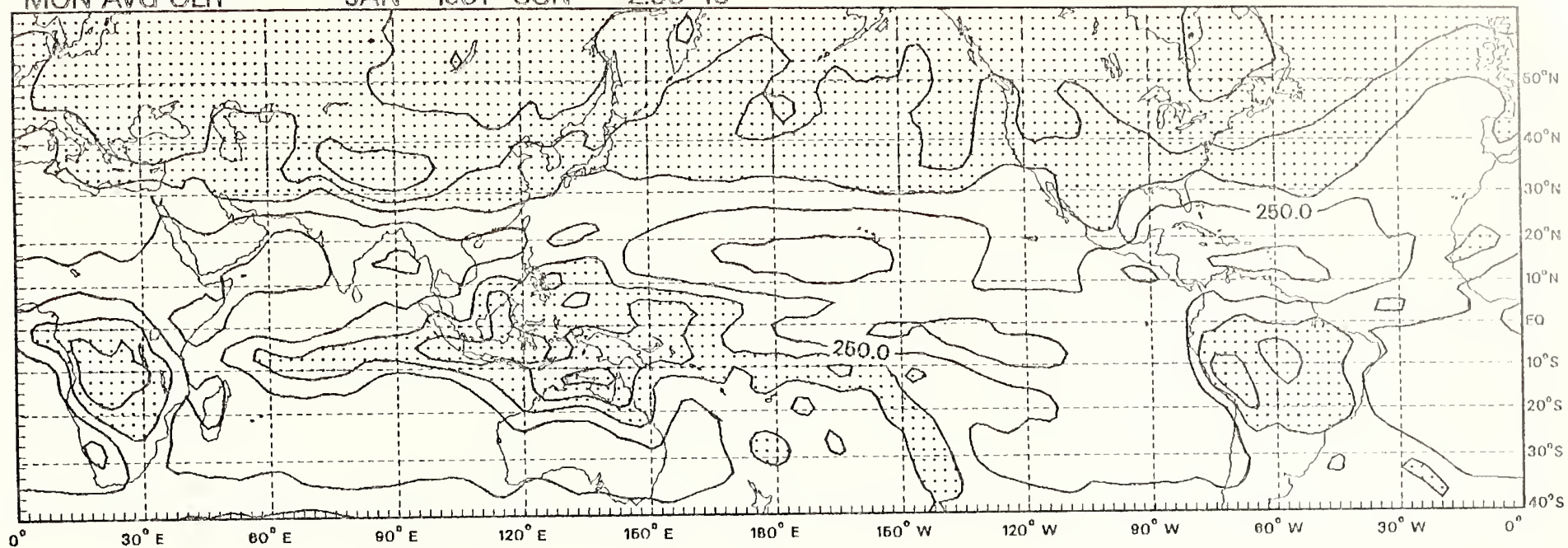
DEC 1980 CON =  $10.00 \times 10^0$

D48



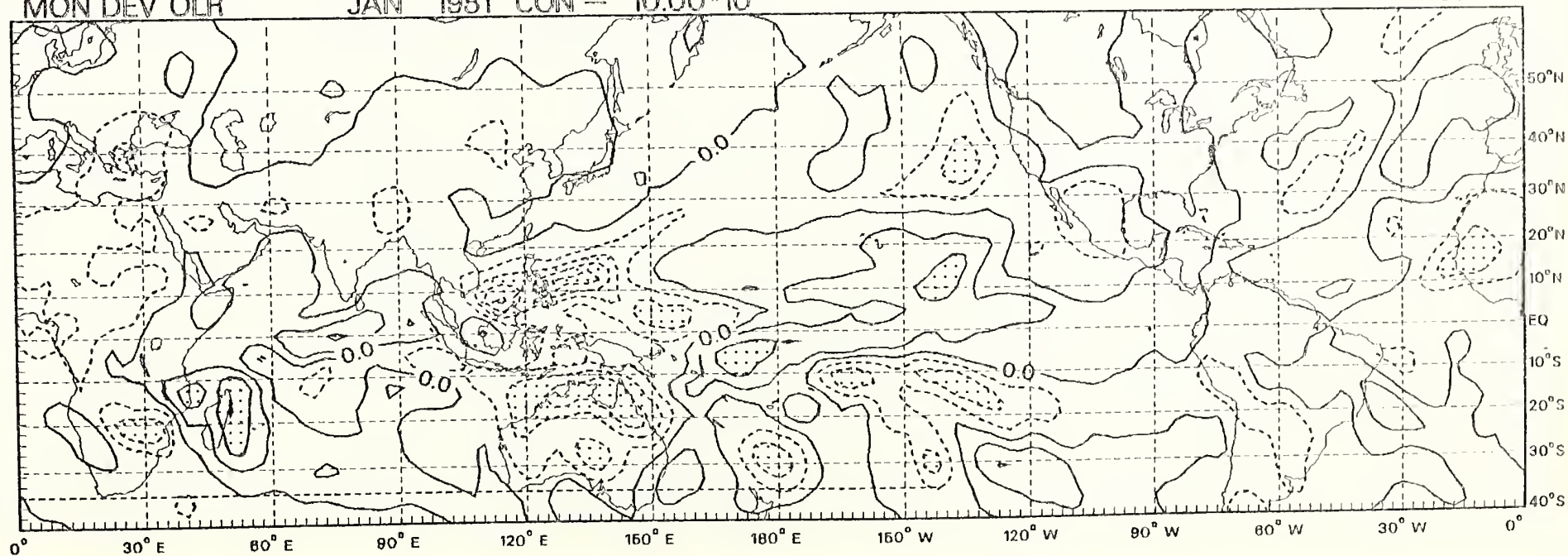
MON AVG OLR JAN 1981 CON =  $2.50 \times 10^1$

D49



MON DEV OLR JAN 1981 CON =  $10.00 \times 10^0$

D50

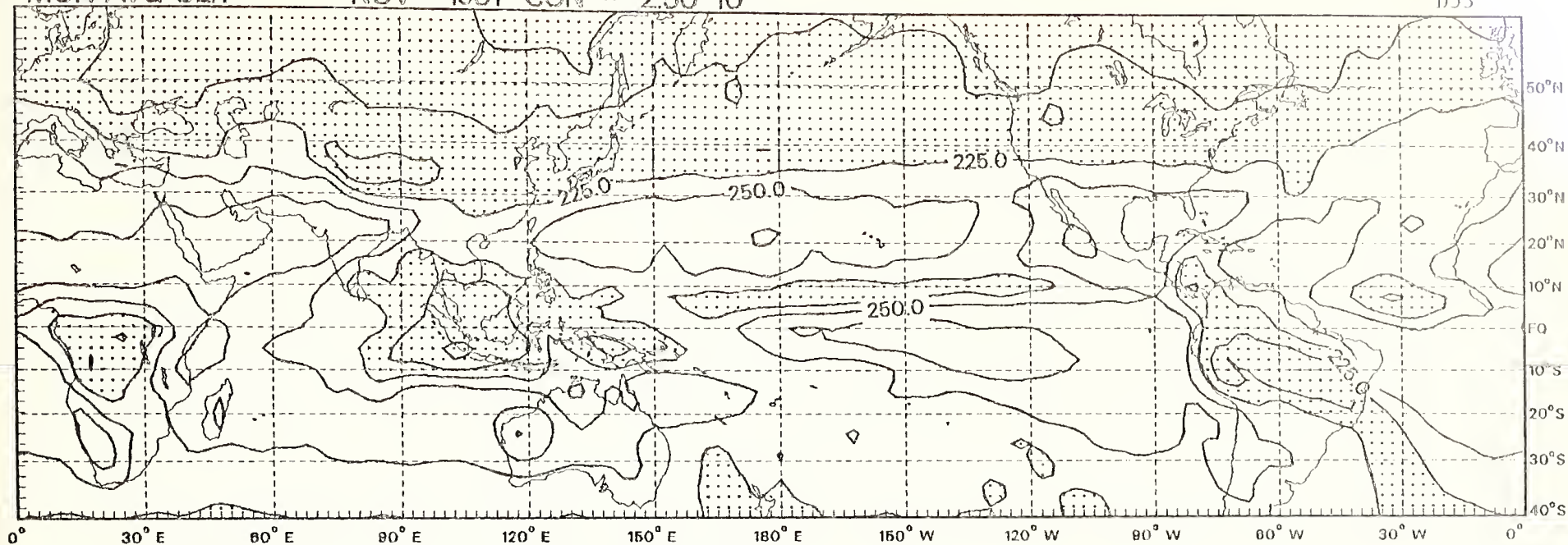




MON AVG OLR

NOV 1981 CON =  $2.50 \times 10^1$

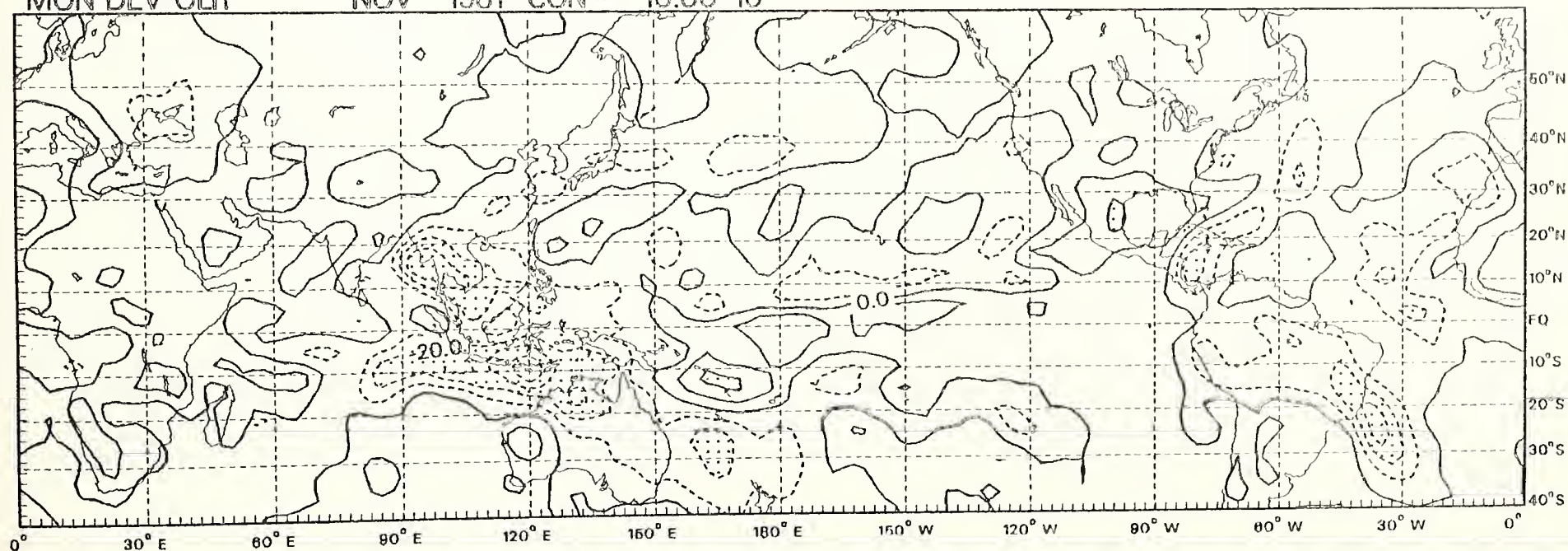
D53



MON DEV OLR

NOV 1981 CON =  $10.00 \times 10^0$

D54

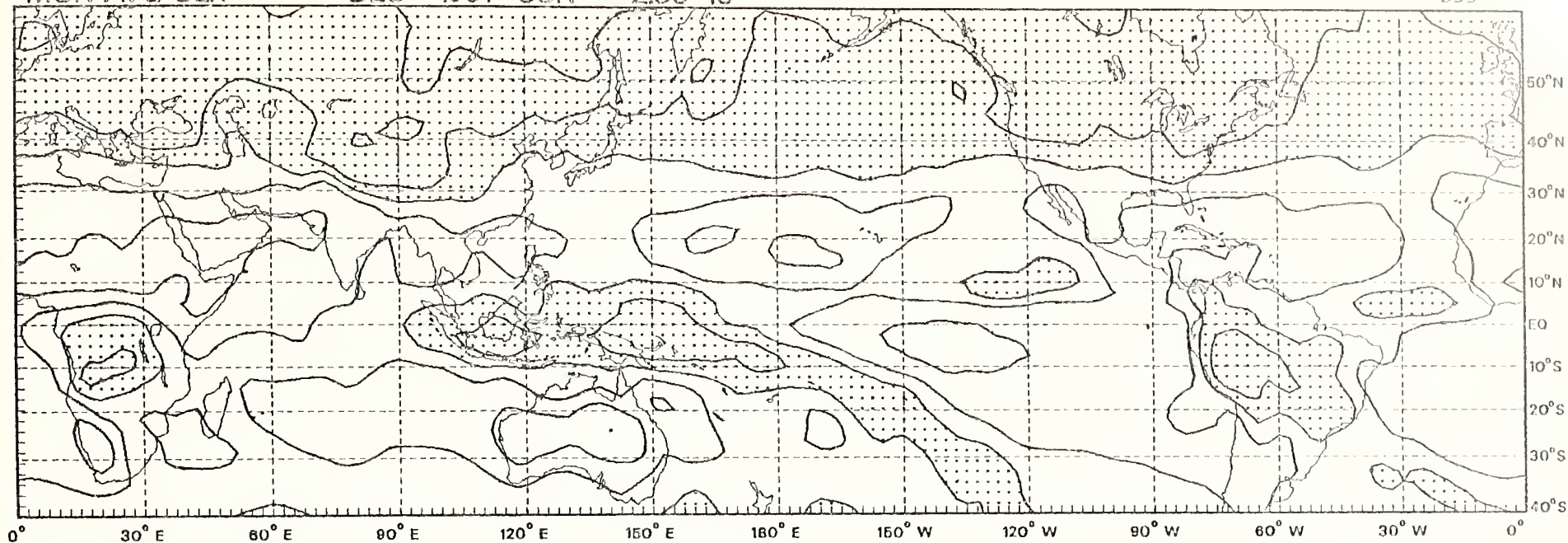




MON AVG OLR

DEC 1981 CON =  $2.50 \times 10^1$

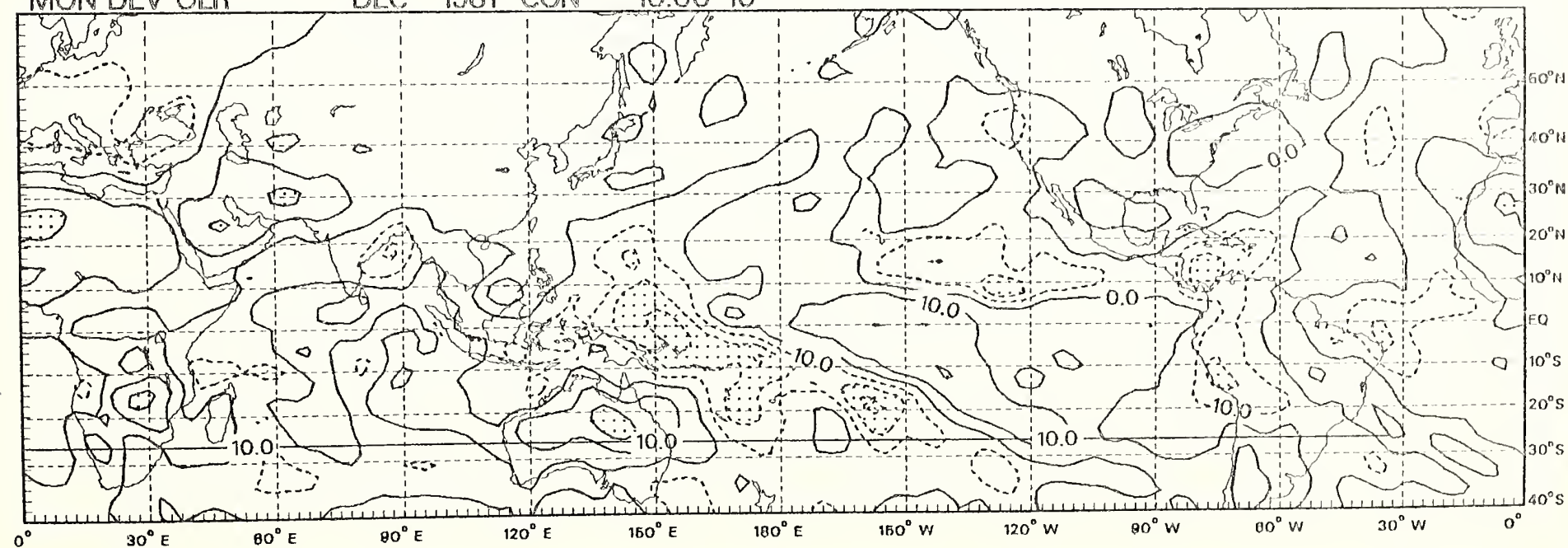
D55



MON DEV OLR

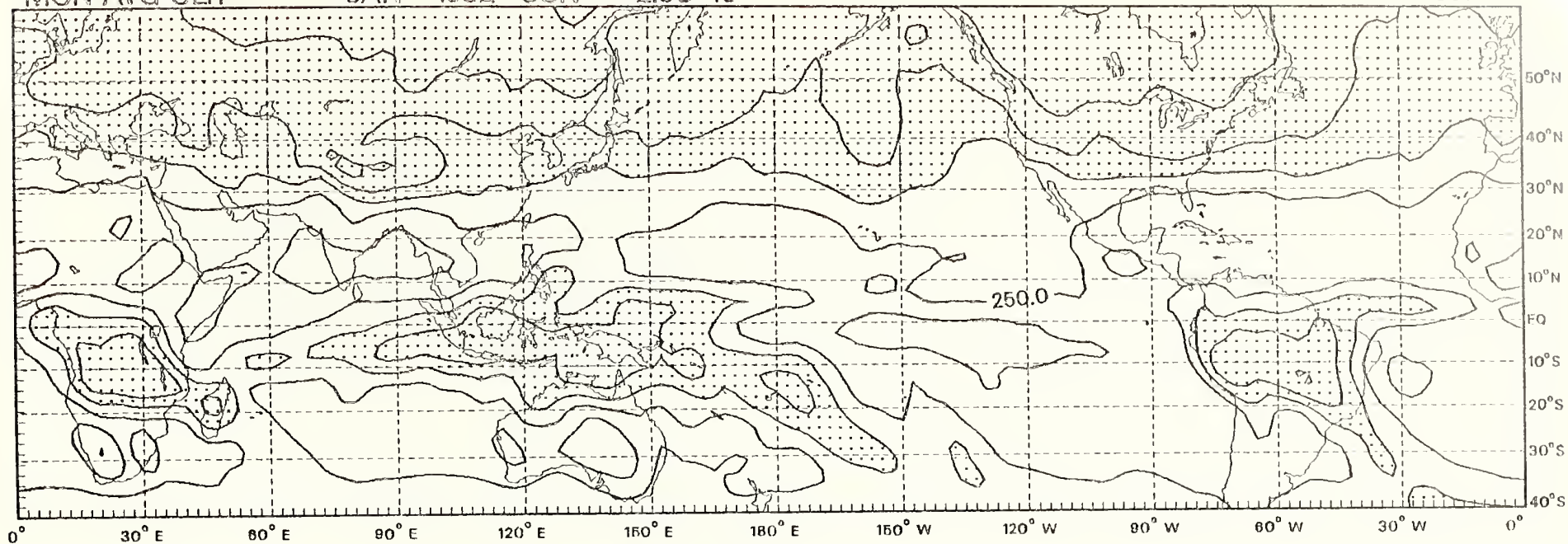
DEC 1981 CON =  $10.00 \times 10^0$

D56



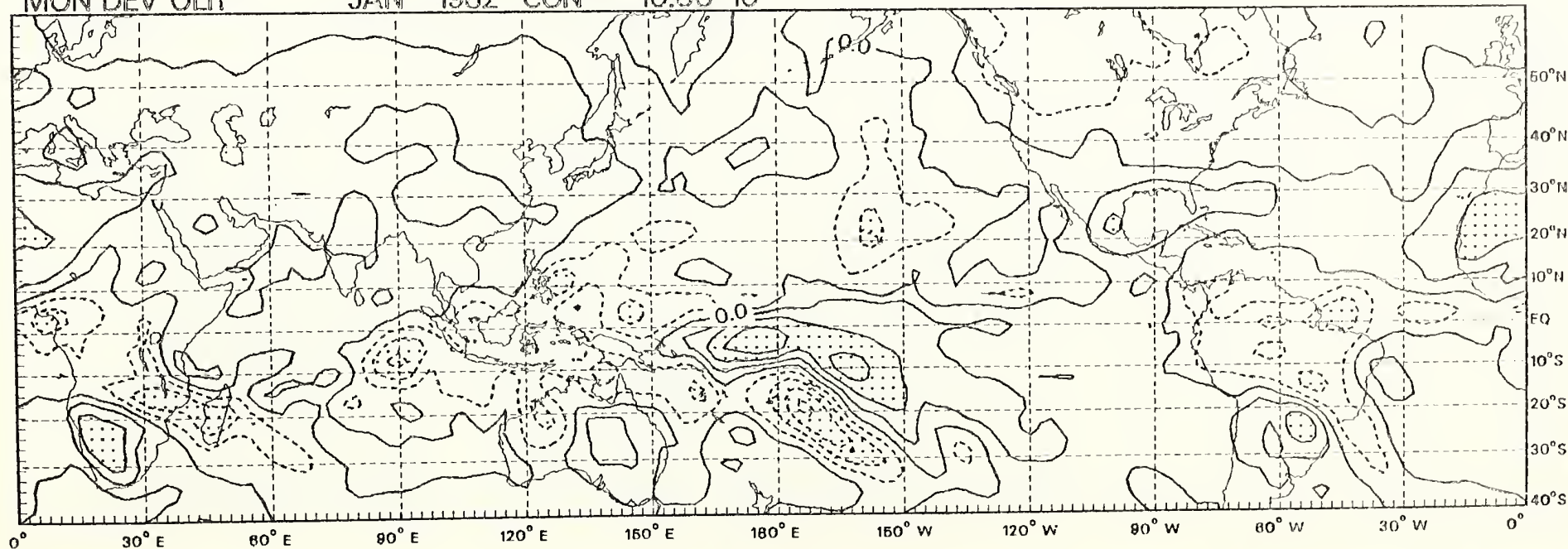
MON AVG OLR JAN 1982 CON =  $2.50 \times 10^1$

D57



MON DEV OLR JAN 1982 CON =  $10.00 \times 10^0$

D58

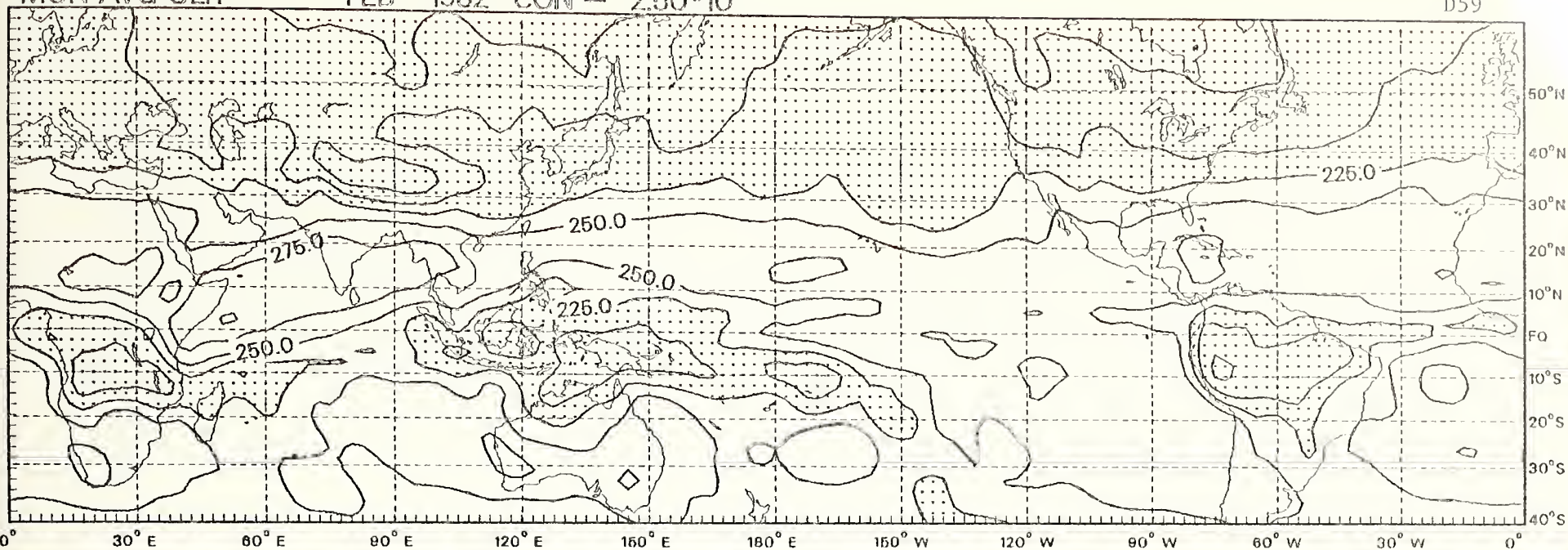




MON AVG OLR

FEB 1982 CON =  $2.50 \times 10^1$

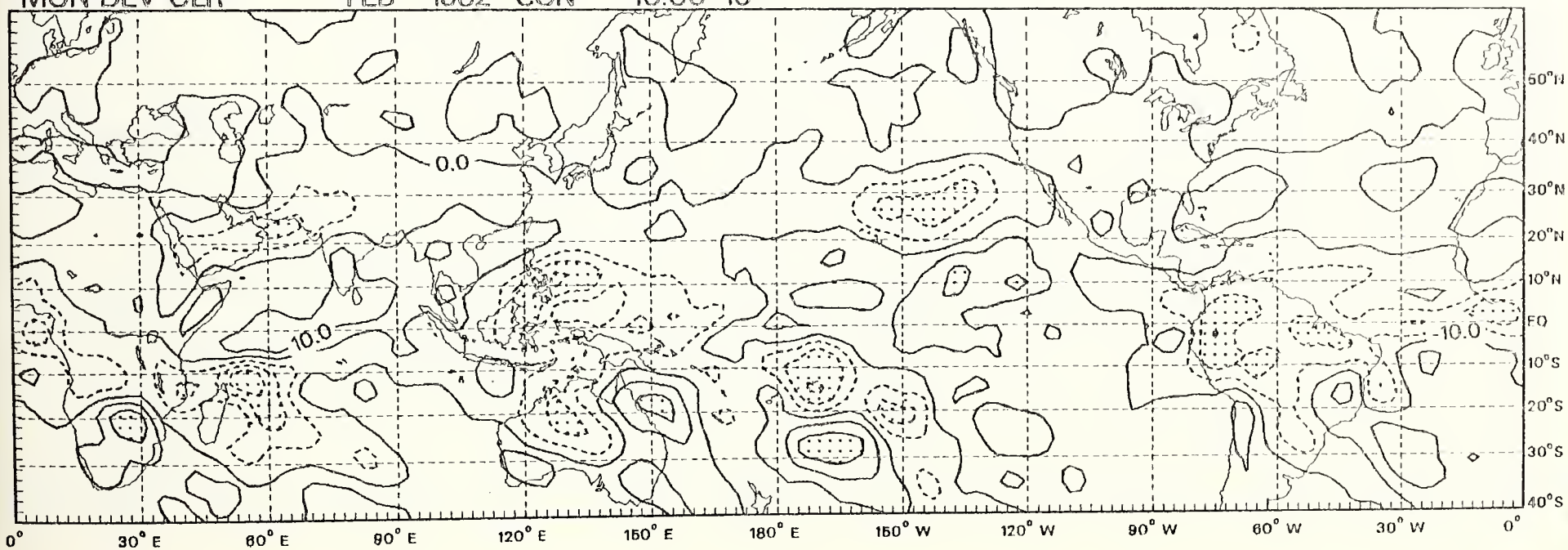
D59



MON DEV OLR

FEB 1982 CON =  $10.00 \times 10^0$

D60

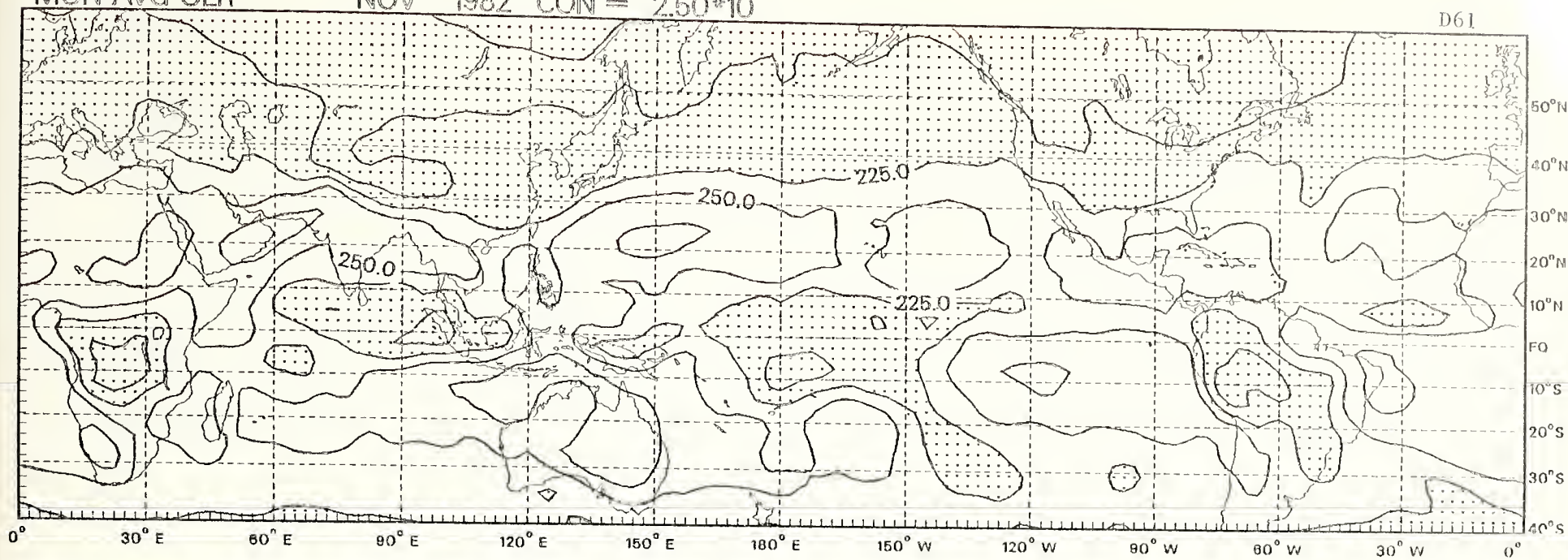




MON AVG OLR

NOV 1982 CON =  $2.50 \times 10^1$

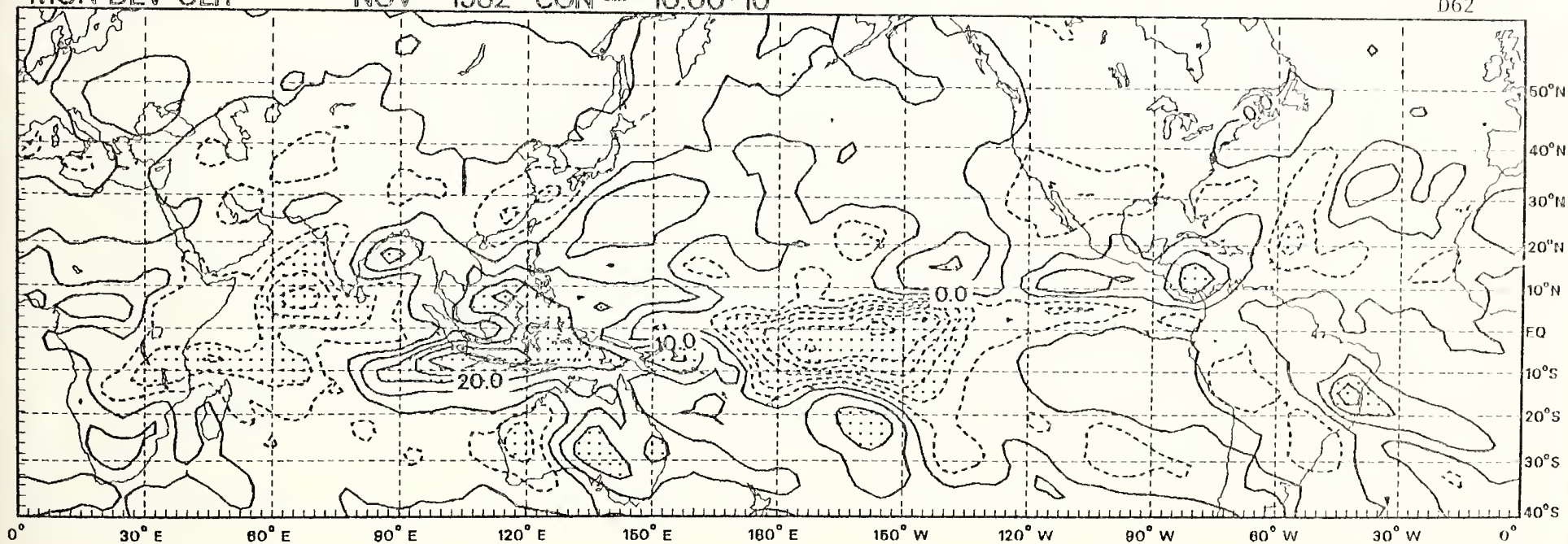
D61



MON DEV OLR

NOV 1982 CON =  $10.00 \times 10^0$

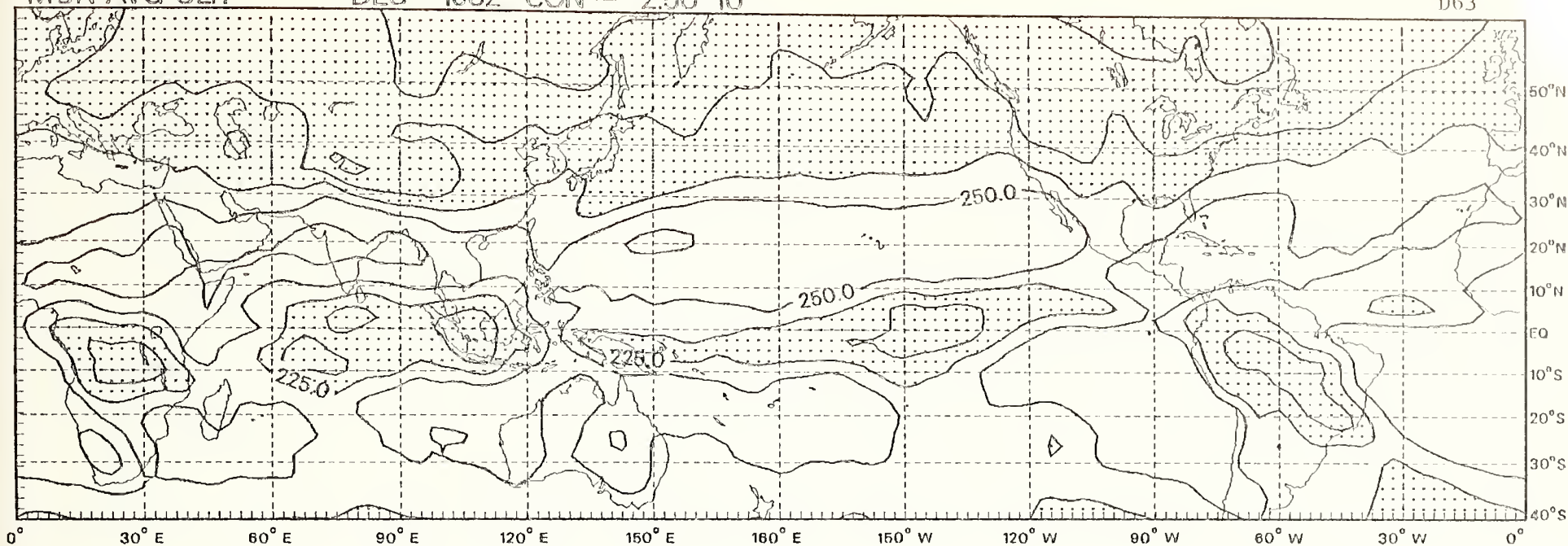
D62



MON AVG OLR

DEC 1982 CON =  $2.50 \times 10^1$

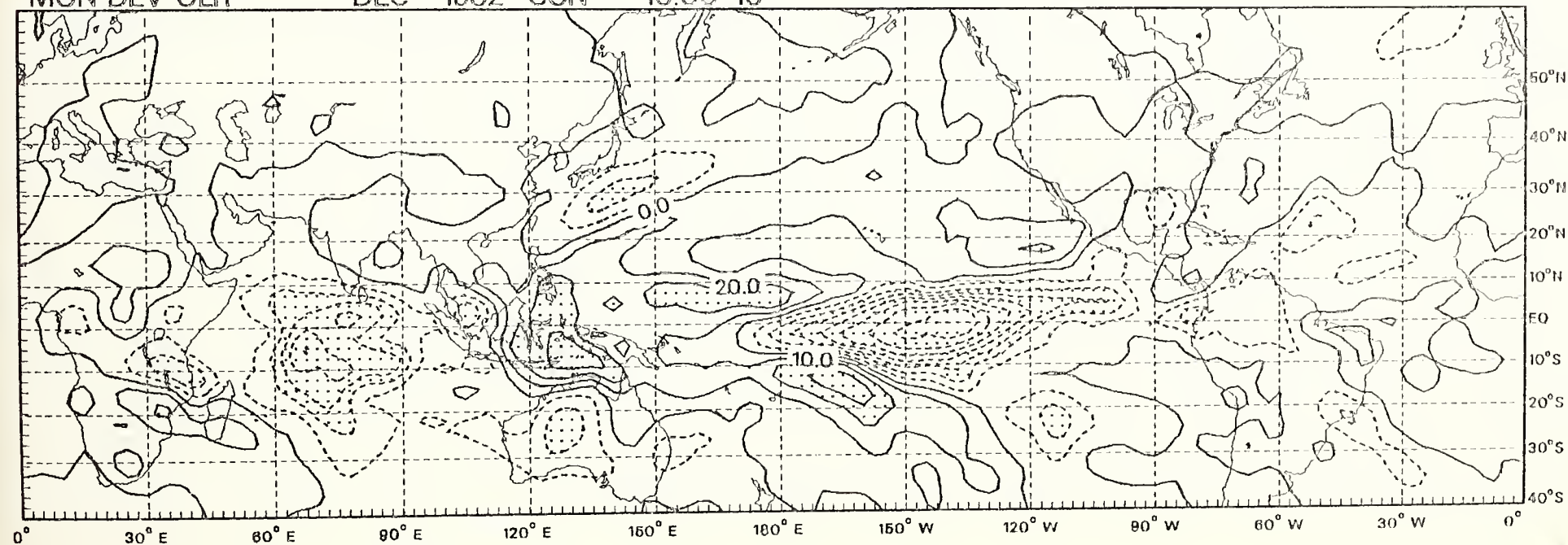
D63



MON DEV OLR

DEC 1982 CON =  $10.00 \times 10^0$

D64

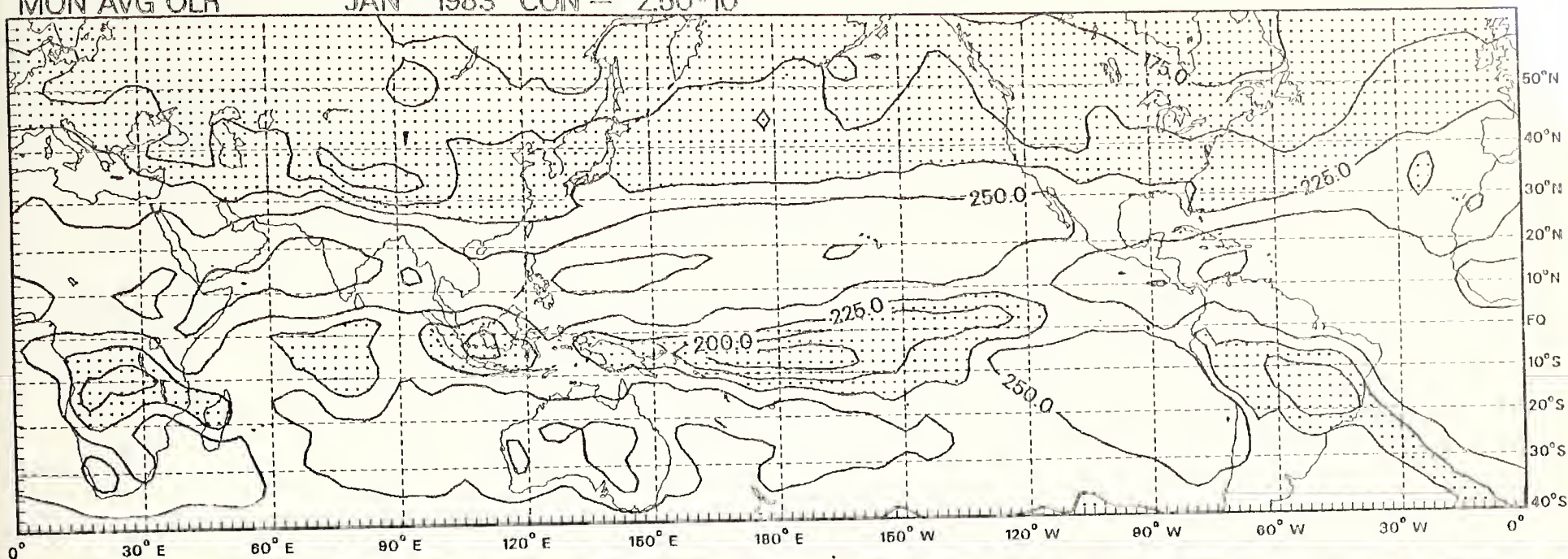




MON AVG OLR

JAN 1983 CON =  $2.50 \times 10^1$

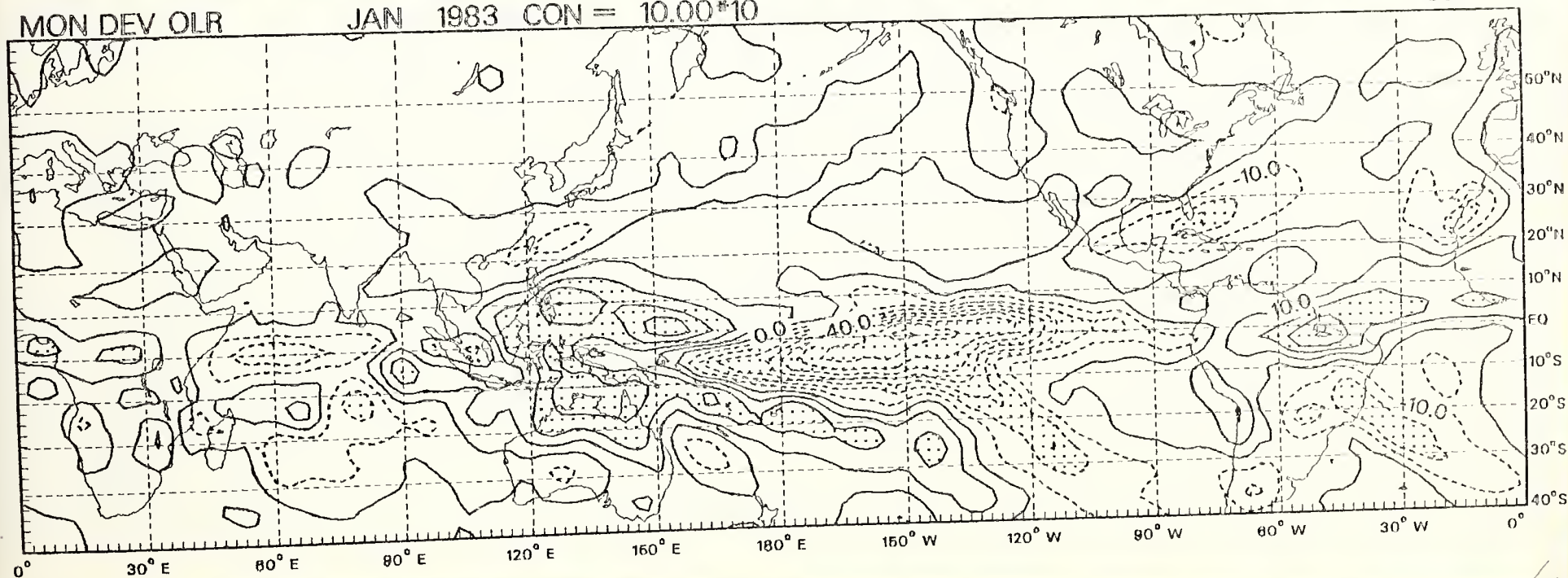
D65



MON DEV OLR

JAN 1983 CON =  $10.00 \times 10^0$

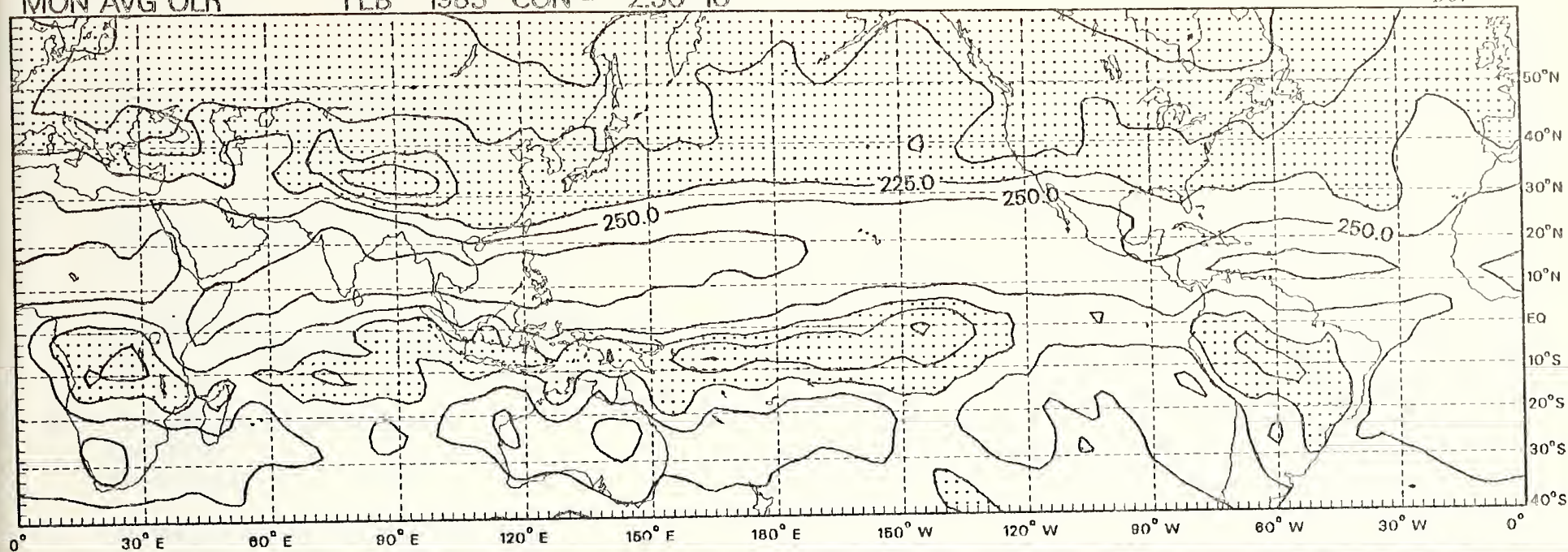
D66





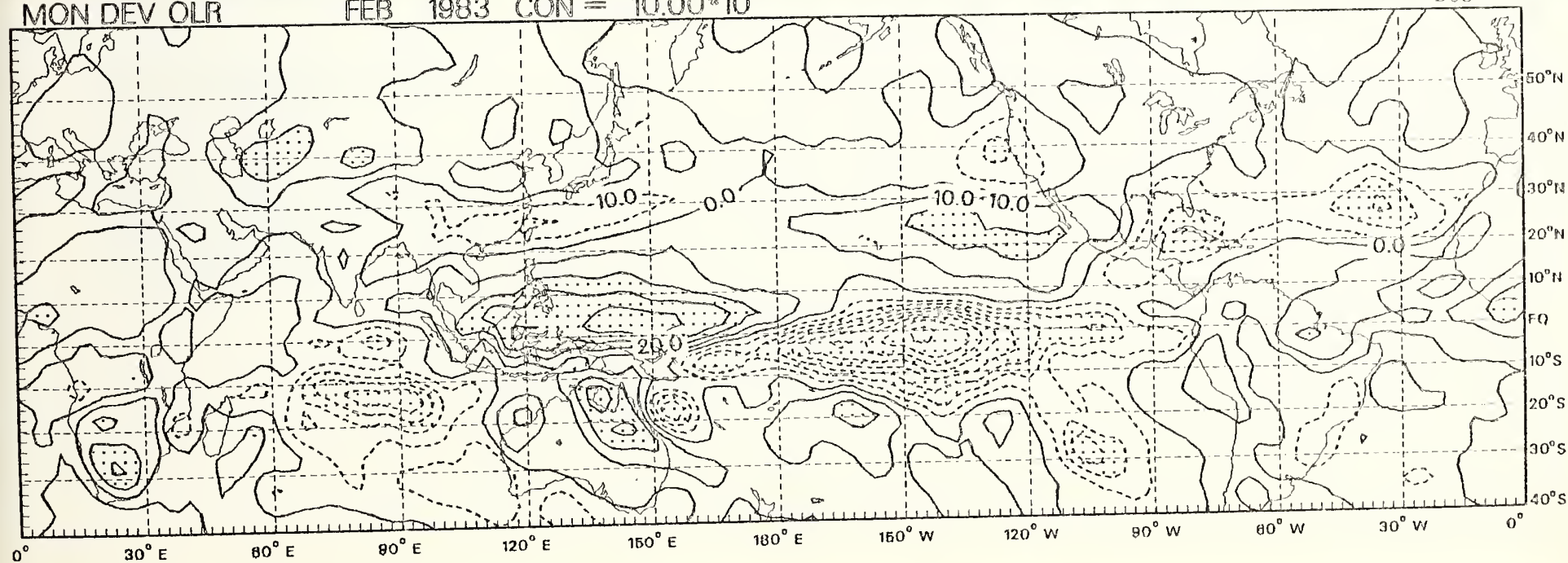
MON AVG OLR FEB 1983 CON =  $2.50 \times 10^1$

D67



MON DEV OLR FEB 1983 CON =  $10.00 \times 10^0$

D68



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